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Nuts & Volts

June 2000
Vol. 21 No. 6

Exploring Electronics And Technology For A New Millennium

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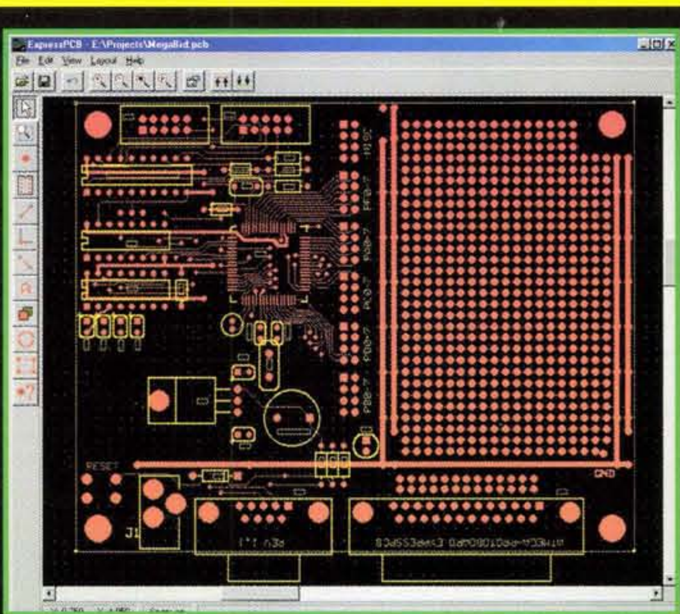
1.

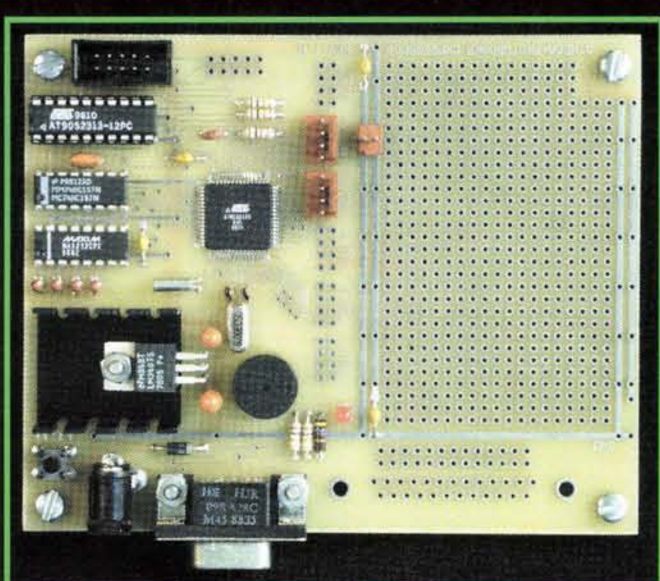
Go from this:



This is a sample project for our design contest. The first step is to lay out a circuit board using the ExpressPCB editor. Your project could be robotic like this one, or related to telecommunications, ham radios, PC computer devices, microcontrollers, scientific equipment, data logging, or almost anything else using an electronic circuit.

2.

To this:



This circuit board controls three RC-servos. The heart of the electronics is a surface-mount Atmel ATMega microcontroller.

3.

To this:

This robotic leg and foot was originally designed for movie special effects. It is a prototype mechanism used to animate small creatures.

1st Prize
Tektronix TDS-210 Digital Oscilloscope

2nd Prize
Palm Pilot V Organizer

3rd Prize
Palm Pilot V Organizer

Contest Rules:

- Enter the contest by submitting a written description and photographs of a working electronic project that you have designed.
- Each project must be built using an ExpressPCB circuit board.
- The circuit board must have been designed by you using the ExpressPCB layout program.
- One grand prize and two second prizes will be awarded to the most interesting projects.
- The winning projects will be announced in the September 2000 issue of *Nuts & Volts* and on the ExpressPCB website. Project photographs and descriptions will be published for each of the winners.
- All entries must be received on or before July 19th, 2000.
- Please note: The materials submitted with each contest entry will become the property of *Nuts & Volts Magazine* and will not be returned.

How to enter:

Each contest entry must include:

- Your name, address, phone number, and E-Mail address.
- A written description of your project, about 250 to 500 words.
- A close-up photograph showing your assembled circuit board.
- One or two photographs of your completed project shown in use.
- The confirmation number given when your ExpressPCB circuit boards were ordered.

To enter by mail, send a hardcopy of your contest entry to:

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Design Contest
430 Princeland Court
Corona, CA 92879

To enter by E-Mail, send a single PKZip attachment to: designcontest@nutsvolts.com. *PLEASE DIRECT ANY QUESTIONS TO:* support@expresspcb.com.

Note: Project descriptions must be Microsoft Word documents or text files and photographs must be high resolution .TIF or .JPG files (.TIF preferred).

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Contents

articles

columns

Classified Ad Index

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YOUR GPS EQUIPMENT NOW HAS BETTER ACCURACY

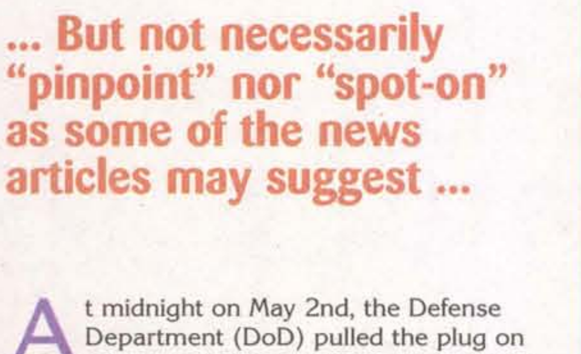
by Gordon West

Your GPS is now more accurate than ever before!

... But not necessarily "pinpoint" nor "spot-on" as some of the news articles may suggest ...

At midnight on May 2nd, the Defense Department (DoD) pulled the plug on intentional signal dithering that created on-purpose position errors and phantom speed errors in our handheld and fixed-mount GPS equipment. Contrary to newspaper and TV news reports, there never was any intentional "jamming" of our civilian GPS signal. And, contrary to news reports, we would not magically acquire the military more-precise signal. And a major contrary to news releases would be the fact that our position accuracy would certainly improve, but not be within the radius of a manhole cover as several news services described.

With selective availability turned to zero, our position probability would shrink from the radius of a 300-foot circle down to the radius of a 60-foot circle. For mariners, this means you still need to be careful when shooting that very narrow channel entrance while watching your position on an electronic chart plotter. And the new "pinpoint" GPS signal still won't get you right back to your specific slip, either.



Navigating to touching-distance to a charted mark.

Those of you that may take your equipment off the boat and use it in the car, land mapping GPS receivers may no longer show you traveling slightly left or right of the major highway. Now you'll be square on the highway, but you still won't be able to tell the difference between your position in southbound lanes versus northbound lanes. You won't be able to tell the difference between your position on the east side of the street versus the west side of the street. And you still won't be able to pull into your own driveway with just GPS alone, even with selective availability turned to zero.

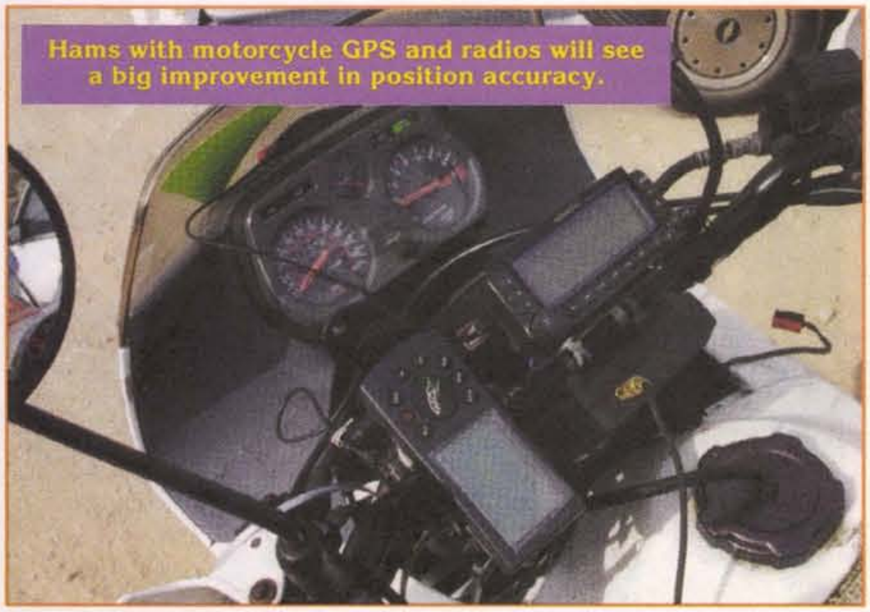
What is "selective availability?" This was the Department of Defense control access to satellite system performance to civilian single-channel receivers. Civilian receivers (as opposed to ultra-expensive classified military receivers) operate on a single channel at 1575.420 MHz, called Channel L1 CA — "CA" for course acquisition of the pseudo-random, spread-spectrum, digital code. Selective availability allowed the Department of Defense to introduce small clock errors in the satellites to constantly run your received position all around the radius (center to out) of a 300-foot circle. This would lead to position errors that would seem to "float slowly" within the radius of this 300-foot circle, sometimes putting you at the right edge of the circle, and then in a few minutes, all the way to the left of the circle, with a TOTAL error of up to 600 feet!

If you could ask the right DoD official why they would constantly run the GPS system with S/A turned on, they would say it was in the best interest of national security. Without S/A turned on, one might assume that unfriendly forces could launch a warhead and — on civilian frequencies — guide it to the big open mouth of that nuclear reactor sitting on Five Mile Island. The way I see it, even if they missed by 300 feet, they would probably be close enough to consider their distant target via GPS a direct hit!

Over the last couple of years, there has been pressure waged on the Department of Defense to "get real" about their civilian channel GPS fears, and turn off purposely introduced errors and let millions of Americans get the most out of their inexpensive GPS receivers. The Commerce Department estimates the commercial GPS market — made up of civilian and commercial users — will reach $16 billion this year, and could easily double during the next three years. President Clinton indicated years ago he was trying to work out this S/A issue and, in a surprise move, somehow pulled it off seconds before midnight on May Day.

"The timing of the S/A on-purpose, clock-error signal caught most of us by surprise, although all of the GPS industry had been anticipating this move sometime within this year," comments Jim Rhodes, a manufacturer representative for Leica Geosystems, Inc., a pioneer in civilian, commercial, and military GPS equipment.

"This timing works out nicely for the worldwide ITU (International Telecommunications Union) conference scheduled next week in Geneva," adds Rhodes, indicating that the elimination of this clock-error signal could be an


Hams with motorcycle GPS and radios will see a big improvement in position accuracy.

important discussion item when all countries come together and discuss mutual and proprietary worldwide navigational systems. Keep in mind that our constellation of 28+ spare satellites in mid-earth orbit continuously beam down navigational signals throughout the world with anyone able to use these signals anywhere in the world. Just ask any Desert Storm veteran how useful civilian GPS equipment was when trudging through the sand with no visible landmarks in sight. Coincidentally, during this conflict, it was reported that S/A was turned to zero by DoD because most of the GPS equipment was off-the-shelf Magellan and Garmin portable receivers!

When Desert Storm was going on over there, sailors out here could easily see improved accuracies in their readouts on electronic chart plotters.

"It has been many years since I have seen nice repeatable position fixes on my GPS as I see today," comments William Alber, a marine electronics technician out of the San Francisco Bay area. "Instead of floating all around our local anchorage, my position shows me within yards of where I am standing on deck," adds Alber.

BUT HOW CLOSE?

In a statement by the President of the United States, our leader comments, "... I am pleased to announce that the United States will stop the intentional degradation of the Global Positioning System (GPS) signals available to the public ... This degradation feature we called Selective Availability (S/A) ... THIS WILL MEAN THAT CIVILIAN USERS OF GPS WILL BE ABLE TO PINPOINT LOCATIONS UP TO 10 TIMES MORE ACCURATELY THAN THEY DO NOW ..." comments the President.

But will the improvement truly give us pinpoint readouts? Will repeatability ever be as good as Loran-C, cycle matching down to just a couple of feet of error most times?

Certainly we will see a many-times improvement in our indicated position on a marine electronics chart plotter or automobile electronic map readout. On the first day without S/A turned on, the repeatability of my static position stayed within the 20-meter ring almost all the time, with a collection of position fixes half the time within my 15-meter radius ring. But keep in mind that 15 meters off from center could be as much as 30 meters total error of a spot I had momentarily saved a few hours earlier. This is more than the length of an olympic swimming pool; and if you are using your equipment to get back within feet of that secret spot, you still won't be able to do it with GPS and S/A turned to zero.

"One of the most important aspects of being 'S/A free' is improvement in differential GPS performance," comments Thomas Stansell, Jr., Stansell Consulting, in his March 22 paper, "Benefits of an Early End to S/A" (tom@stansell.com).

"Without selective availability, acceleration errors essentially will be zero, and velocity errors will be extremely small — thus, the key advantage of the elimination of S/A will be to increase greatly the time interval between the DGPS corrections needed to maintain the same or better accuracy," adds Stansell, discussing the United States Coast Guard's low/medium frequency differential beacon system in place throughout our country's ports, and the plans for additional low/medium frequency differential beacons sending stations throughout the inland country that could be used by the Department of Transportation and railroads.

With increased position and velocity accuracies with S/A now turned to zero, do we still need the differential correction? The answer is an absolute yes to meet certain Federal require-


Hams using GPS automatic position reporting systems will have a big improvement in accuracy.

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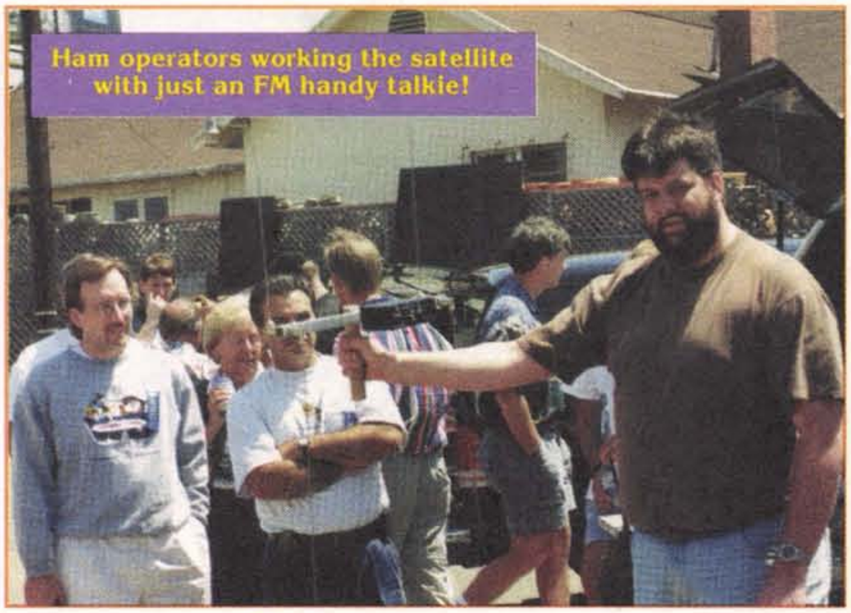
ments for ocean harbor approach procedures and getting those big 747s down the center of the runway — NOT a few feet too far left or right — port or starboard. Would switching to the military's L2 1227.600 MHz precise P-code channel give us the same, if not better, "spot-on" position repeatability and capability as differential signals coming in from a companion low/medium frequency receiver? Nope — signals alone from the GPS satellites without ground timing checks may suffer some unexpected non-predictable and non-modelable slowdowns or accidental equipment speed-ups as seen in this error budget summary:

• Satellite clock error	10-20 feet
• Ephemeris error	10-20 feet
• Receiver error	15-40 feet
• Atmospheric & ionospheric errors	100-200 feet
• Selective Availability	Up to 300 feet

When you add all of these possible errors up, you can now begin to see why repeatability errors of a specific position fix might be hundreds of feet off. And even with S/A turned to zero, those atmospheric and ionospheric anomalies might change dramatically over a 24-hour period based on atmospheric conditions called tropospheric ducting, and ionospheric conditions called D-layer, E-layer, and F-layer absorption and refraction.

Military receivers using parallel L1 and L2 receivers would help minimize atmospheric and ionospheric errors by comparing incoming time delays to the passing satellites. But even the military equipment can't get down to feet and sub-meter accuracy without help from land-based monitors which are designed to compare incoming pseudo-random signals from precise geodetic positions they have located, and coming up with error correction signals (differential) that are then transmitted to local strap-on GPS receivers attached to your civilian-type GPS equipment.

These "strap-on" receivers could allow free differential signal reception from low/medium frequency, thanks to the United States Coast Guard, but signals down on these lower frequencies are tough to receive more than 50 miles away from the transmitter. And, as soon as you turn on any type of noisy electronic equipment nearby, US Coast Guard differential beacon reception might only be possible within just 10 to 20 miles of their shore-based transmitters. And inland, for the time being, no low-frequency corrections are readily available free of charge.



Ham operators working the satellite with just an FM handy talkie!

Yes, you can pay for UHF correction signals, and these are rebroadcast by powerful FM music stations as part of their sub-carrier access (SCA). Surveyors may use this feature to get themselves down to specific fire hydrants or manhole covers.

For sub-millimeter accuracy, we still use our GPS satellites, but introduce local UHF and microwave equipment to compare pseudo and incoming positions to a differential readout that could get you down to the radius of your Indian head nickel. But again, you must pay for this service.

Exactly *how* someone receives a differential beacon signal has gone several different ways, where surveyors use UHF and microwave frequencies, motorists and delivery services may use sub-carrier access on FM radio signals, and the United States Coast Guard chooses to re-use old low-frequency beacon stations by offering position correction updates via minimum shift keying (MSK) to anyone — free of subscription charge — who has purchased a $500-$700 add-on differential beacon receiver. But for the portable market, or the market where you can't have a huge low-frequency antenna sticking out of your vehicle, you can imagine the relatively complicated — and sometimes costly — decision process.

Now enters the Federal Aviation Administration (FAA), and well-respected military and marine electronic provider Raytheon and their wide area augmentation system, nicknamed "WAAS." This may be the ultimate free way of upgrading your portable or fixed-mount GPS position fix from the radius of a 20-yard circle all the way down to a couple of feet — and the system is operational right now, but WAAS DGPS has yet to be completely implemented based on its current review for government funding. WAAS indeed incorporates land stations at a specific geodetic surveyed spot that compares satellite-arriving GPS signal position readouts to their own known position.

The ground station then crunches the data into a differential correction, and this is uploaded to the geosynchronous INMARSAT system operated by the consortium COMSAT. The geostationary COMSAT repeats the differ-

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Testing new GPS accuracy after S/A is turned to zero. Position errors were less than 40 feet!

ential correction as one of the L1 civilian GPS channels where Raytheon WAAS-equipped receivers take this one additional channel of satellite-borne information, and correct the mid-earth orbit calculations to the more precise WAAS corrected readout.

Best news here is no additional bulky, low-frequency, Coast Guard beacon receiver is needed. No extra monthly bill for FM sub-carrier corrections, and no need for multi-thousand-dollar portable correction stations. Via the WAAS signal coming down on the same satellite spread-spectrum frequency as the mid-earth-orbit GPS satellites, one little receiver with the proprietary Raytheon WAAS-added decode channel does all!

The FAA is now in its first phase of installing and testing numerous reference stations, two master stations, and two leased INMARSAT satellites. They have worked out the problems with correction and verification software glitches, and things are going along nicely with the FAA hoping to receive continuous funding on the WAAS project to ultimately allow it to shut down aeronautical instrument landing systems and turning off older systems like OMNI and some very old low-frequency beacon stations.

It may be years before WAAS is a sole aeronautical navigation system, but things are looking quite positive that there may be other transportation groups that may jump aboard the WAAS band wagon. I would hope the United States Coast Guard would see the advantages of WAAS over their antiquated way of sending minimum shift-keying corrections on the old 300 kHz-500 kHz beacon band. Come on now, reception range of 100 miles versus half the world?

During recent testing with Raytheon electronics aboard test boats on both the East Coast, as well as the West Coast, a simple single Raytheon GPS receiver-in-the-antenna system proved how well WAAS works. With just GPS and S/A turned on, we could only get within a couple hundred feet of a navigational piling and be assured we wouldn't really run into it. Tests today without S/A turned on got us as close as 60 feet of the piling before we were uncertain that we were on top of it or not. But tests a week ago with S/A on and with WAAS allowed us to get within 10 feet of the piling. Tests today with WAAS and without S/A turned on allowed us to stand on the bow of the boat with the GPS/WAAS receiver/antenna in one hand and physically touch the piling in the middle of the channel with our other hand.

WAAS for the FAA is well within the required teens of feet necessary to put the nose wheel right down the center line of a runway, with equal elevation figure checks that GPS alone has not been able to do well.

When we went to compare WAAS with the local low-frequency Coast Guard differential system, we had a hard time locking onto the Coast Guard frequency because of onboard running refrigeration equipment. And that's one of the big problems with the Coast Guard system — the noise that most boats create down on low frequency is so natural that it regularly wipes out low-frequency reception.

The benefit of WAAS, now with the added benefit of no S/A turned on, is continuous updates without atmospheric or onboard noise problems, no additional strap-on receiver required, no additional big bulky antenna, no monthly service fees, "good enough for the FAA" integrity insurance, and the new Raytheon receiver with the added WAAS satellite capability is only about $200.00 more than a conventional Raytheon receiver/antenna system. That antenna system works quite nicely with Raytheon color and monochrome chart plotters, too.

So enjoy improved GPS accuracy right now thanks to the Department of Defense finally giving in to millions of Americans saying it's absurd to purposely reduce GPS accuracies that are easily reinstated with local or WAAS correction signals. Now that S/A is turned to zero, local differential beacon signals and those from WAAS can live up to the President's expectation of being "spot-on."

Does differential reception still have importance within the GPS system? Absolutely so — if you're trying to navigate down an extremely narrow channel, or locate that underwater gold piece you spotted on the last scuba trip, or track down a cell phone user calling 911 on the side of the road with chest pains and an imbedded GPS position, differential corrections are indeed still necessary.

As for me, I would take WAAS any day over the antiquated low/medium frequency local correction signals that the US Coast Guard is trying to jam through all the onboard noise. WAAS with the FAA backing appears to be the best way to go if you need more accuracy than the tenfold improvement we just received on May Day thanks to the turn-off of selective availability. **NV**

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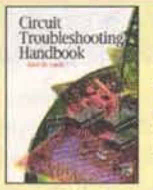

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Open Channel

by Joseph J. Carr

Noise Cancellation Techniques

> **Noise is bad. Whether you operate a radio receiver, or some piece of scientific or medical instrumentation, noise interferes with acquiring desired signals. After all, radio reception and other forms of signal acquisition are essentially a game of signal-to-noise ratio (SNR).**

The actual values of the desired signal and noise signal are not nearly as important as their ratio. If the signal is not significantly stronger than the noise, then it will not be properly detected.

Getting rid of noise battering a signal is a major chore. Although there are a number of different techniques for overcoming noise, the method described herein can be called the "invert and obliterate" approach.

This same idea was used in a popular novel in which a cranky inventor created a dynamic stealth concept by placing antennas all over an aircraft to receive radar signals, invert them, and then retransmit them 180 degrees out of phase with the incident wave ... thereby causing cancellation.

The idea is also used in actual (not fictional) noise abatement systems in which microphones and loudspeakers are used to retransmit room noises 180 degrees out of phase with the incoming. According to reports I've heard, remarkable reductions in local noise are possible, although the technique tends to fall down over large areas.

Figure 1 shows the basic problem and its solution (cast in terms of radio reception). The signal from the main antenna is a mixture of the desired signal, and a locally generated noise signal. This noise signal is usually generated by the 60 Hz alternating current (AC) power lines, or machinery and appliances operating from the 60 Hz AC lines. The noise signal is not confined to 60 Hz, but will extend into the VHF region because of harmonic content.

The noise spikes will appear every 60 Hz from the fundamental frequency up to about 200 MHz or so, although the harmonics become weaker and weaker at progressively higher frequencies. But in the VLF bands (where they are often overwhelming), AM broadcast band (AM BCB), and medium wave shortwave bands, the noise signal can be tremendous. It will therefore cause a huge amount of interference.

The solution (also shown in Figure 1) is to invert the noise signal, and combine it with the signal from the main antenna. When the phase inverted noise signal combines with the noise signal riding on the main signal, the result is cancellation of the noise signal, leaving the resultant main signal. What is needed is a noise sense antenna, a means for inverting the noise signal, and a summing circuit.

Figure 2 shows a generic case that serves to illustrate the method for both radio reception and other forms of instrumentation. The signal source will be the main antenna in the case of radio reception. But in the case of scientific instruments, it might be some sort of sensor. In a medical case, it could be a human patient with either sensors or electrodes attached (as in an electrocardiogram).

The noise source is the local AC power lines or machinery that radiates a signal of some sort. If the noise signal is picked up by the noise source (or its connecting wires), then it will travel through amplifier A1 and cause interference. But the signal can also be picked up by a small sense antenna, and fed to an inverting amplifier (A2).

By definition, an inverting amplifier shifts the phase of the input signal 180 degrees, so when the inverted noise signal is applied to the summer it will cancel the noise component of the main signal. It might be necessary to provide some amplitude control in order to not replace the main noise signal with a new noise signal from A2.

The case of a radio receiver system is shown in Figure 3. The phase inversion and summation functions of Figure 2 are performed in a special noise cancellation bridge circuit. The main antenna is the antenna that is normally used with the receiver. It might be a dipole, vertical, beam, or just a random length of wire strung between two trees.

The noise sense antenna is optimized for pick-up of the noise source signal. One VLF radioscience observer told me via E-Mail that he uses a 36-inch whip antenna mounted on his roof as the noise sense antenna.

In some shortwave situations, the sense antenna is a 10 to 30 foot length of antenna wire running parallel to the power lines that are creating the noise. **CAUTION:** Under no circumstances should you allow the sense antenna to touch the AC power lines, even if it breaks and whips around in the wind. In

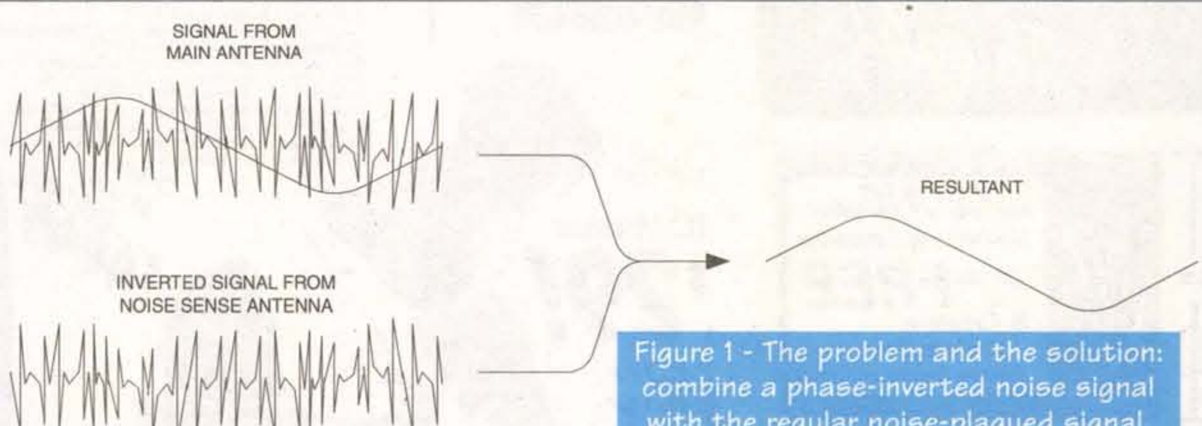

Figure 1 - The problem and the solution: combine a phase-inverted noise signal with the regular noise-plagued signal.

Noise Cancellation Techniques

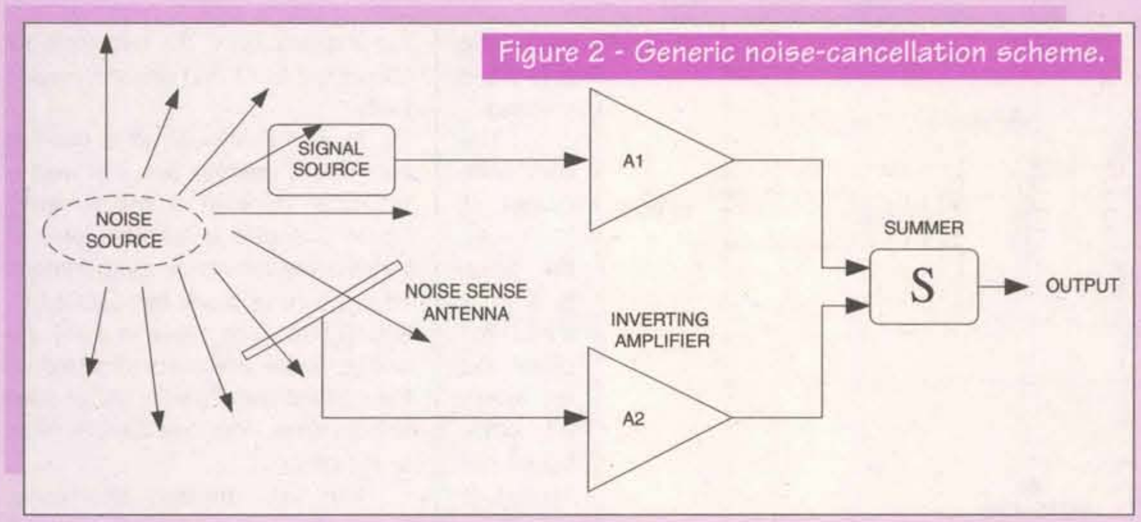

Figure 2 - Generic noise-cancellation scheme.

the case of VHF noise reception, the sense antenna might be a two or three element beam (Yagi or Quad) aimed at the noise source. Other combinations are also possible, I presume.

One goal of the sense antenna is to make it highly sensitive to the local noise field, while being a lot less sensitive to the desired signal than the main antenna. Although in purist terms, both noise and desired signals appear in both antennas, the idea is to maximize the noise signal and minimize the "desired" signal in the sense antenna, and do the opposite in the main antenna.

In the system in Figure 3, the noise sense signal and main signal are combined in a noise canceling bridge (NCB). The output of the NCB is a cleaned-up version of the antenna signal, with greatly improved SNR.

The design problems that must be overcome in producing the NCB are easy to see. First, it must either invert or provide other means for producing a 180-degree phase shift of the noise signal. It must also account for amplitude differences so that the inverted noise signal exactly cancels the noise component of the main signal.

If the amplitudes are not matched, then either some of the original noise component will remain, or the excess amplitude of the inverted noise signal will transfer to the signal and become interference in its own right. The noise signal inversion can be accomplished by transformers, bridge circuits, RLC phase shift networks, or delay lines.

A Simple Bridge Circuit

Figure 4 shows a simple bridge circuit. I've used it at VLF on radio-science observing receivers, and others have used it on VHF receivers. The bridge consists of two transformers (T1 and T2). Transformer T1 is trifilar wound, i.e., it has three identical windings interwound with each other in the manner of Figure 5. The black "phasing dots" or "sense dots" indicate one end of the windings, and will be used for wiring T1 into the circuit of Figure 2.

Winding the toroid exactly as shown in Figure 5 is a difficult task, so you might want to consider an alternative method. Select three lengths of enameled wire (#18 AWG through #26 AWG can be used, but all wires should be the same size). In order to keep them straight in my mind as I work them, I select three different insulation colors from my wire rack.

Tie all of them together at one end, and insert that end into the chuck of a hand drill. I usually fasten the other ends into a bench vice, and back off until the wires between the vice and drill are about straight (more or less). Turn on the drill at a slow speed (slightly squeeze the trigger on

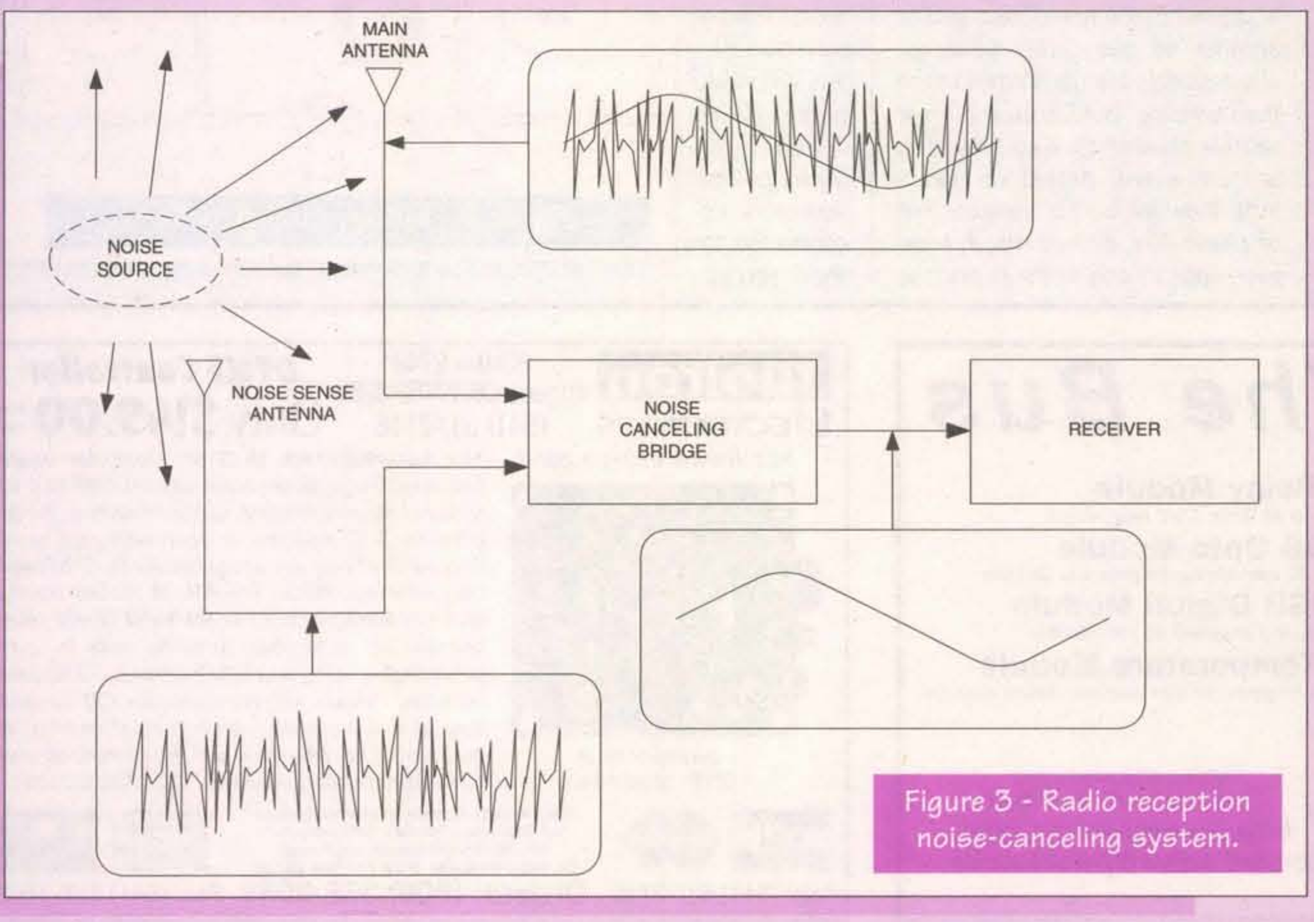

Figure 3 - Radio reception noise-canceling system.

Noise Cancellation Techniques

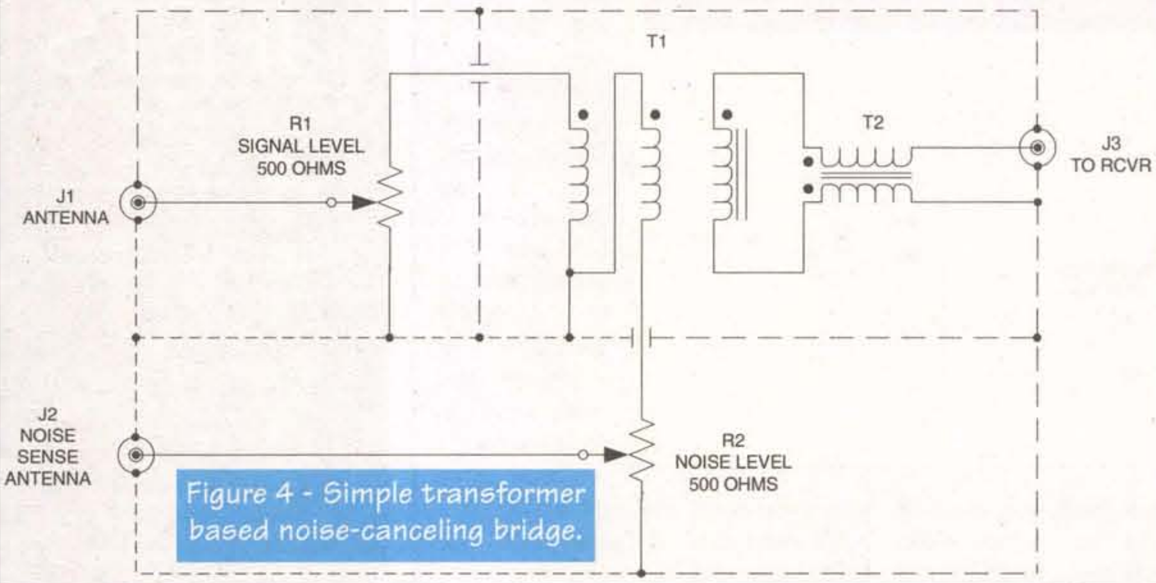

Figure 4 - Simple transformer based noise-canceling bridge.

variable speed drills), and let the drill twist them together. Keep this process going, being careful to not kink the wire (which happens easily!), until there are 8 to 16 twists per inch (not critical).

CAUTION: Wear protective goggles or safety glasses when doing this job. I once let the drill speed get too high; the wire broke and I received a nasty lashing to the face ... which

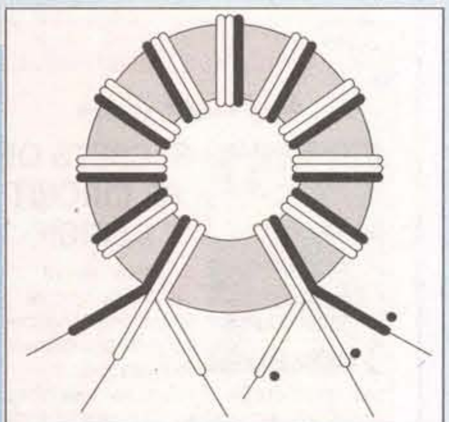

Figure 5 - Trifilar wound toroid transformer.

could've damaged my eye except for the glasses.

Once the three-wire composite wire is formed, it can be wound onto the toroid form as if it were one wire. Before winding, however, separate the ends a bit, scrape off enough insulation to attach an ohmmeter probe, and measure both the continuity of each wire, and whether or not any two are shorted together. If the wires are wound too tight, then it's possible to break one wire, or breech the integrity of the insulation.

Note in Figure 4 the way transformer T1 is wired. The main antenna signal from J1 is connected to the dotted end of one winding, while the sense antenna signal (J2) is applied to the non-dotted end of another of the three windings. These signals are transferred to the third winding, but because of their relative phasing (due to how they are connected, dotted or undotted), they will be 180 degrees out of phase. The desired signal, however, appears only in the J1 port, so will not be phase inverted.

The composite output of T1, i.e., the noise plus desired signal and the inverted noise signal, is applied to transformer T2. This transformer is inserted into the line as a common mode choke, so will perform the actual cancellation of the inverted and non-inverted noise signal components. Transformer T2 is built exactly like T1, but is bifilar (two windings) instead of trifilar.

Signal amplitudes from the two different antennas are controlled by a pair of 500-ohm potentiometers. The pots selected for R1 and R2 should be non-inductive (i.e., carbon or metal film, but NOT wirewound). In other words, rather ordinary potentiometers will work nicely. The wipers of both potentiometers are connected to their respective antenna jacks. The two ends are connected to T1 and ground, respectively.

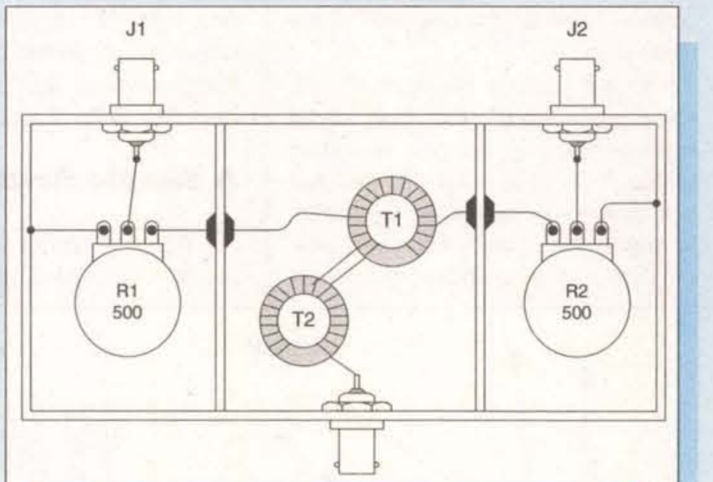

Figure 6 - Shielded construction.

Note that this circuit is not just built into a shielded box, but also in separate shielded compartments. Figure 6 shows a suitable form of building the circuits. A compartmented box such as made by SESCOM (1-800-634-3457) is used to hold the bridge. Small grommets mounted on the internal shield partitions are used to pass wires from one compartment to the other.

For VLF through shortwave, transformer T1 is wound with 16 turns of enameled wired, and T2 is wound with 18 turns. Both can be wound on half-inch cores (T-50-xx or FT-50-xx), but it will be easier to use slightly larger forms such as FT-68-xx, T-68-xx, FT-82-xx, and T-82-xx. Ferrite cores (FT-nn-xx) should be used in the AM BCB and below, while powered iron (T-nn-xx) can be used in the medium wave and shortwave bands.

Recommended ferrite types for VLF through the AM BCB include FT-82-75 and FT-82-77, medium wave units can be made using FT-82-61,

Noise Cancellation Techniques

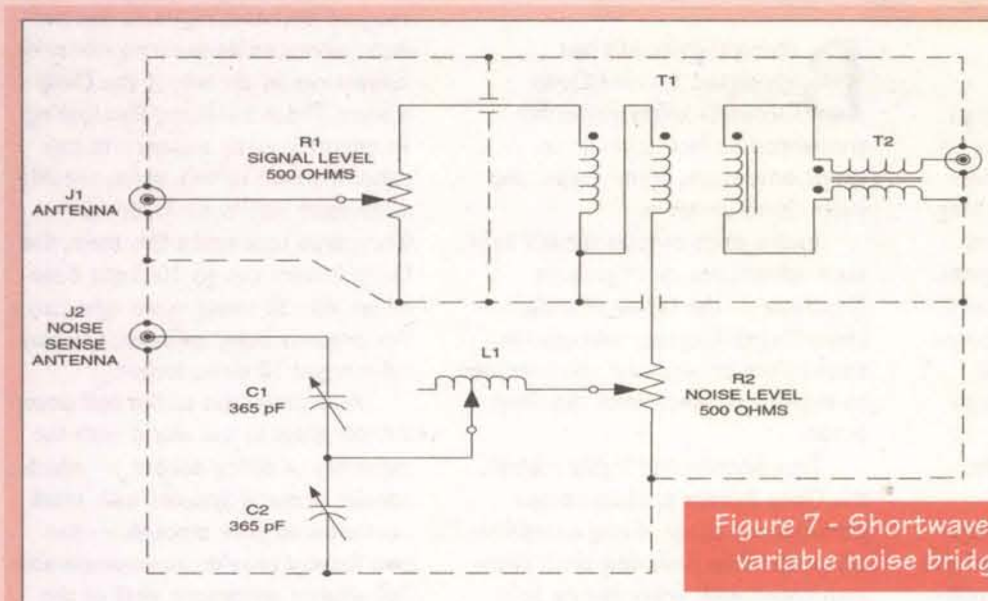

Figure 7 - Shortwave/HF variable noise bridge.

T1: 16 turns, #18 AWG Trifilar wound on Amidon FT-82-61 core
T2: 18 turns, #18 AWG, Bifilar wound on Amidon FT-82-61 core
L1: 32 uH, 45 turns, #22 enameled wire, 1-inch diameter, wire-dia. spaced
R1,R2: 500-ohms, non-inductive
C1,C2: 365 pF trimmer capacitors

and VHF units can be made using FT-67 or FT-68 (or their -50 and -68 equivalents). If powdered iron cores (T-nn-xx) are used, then select T-80-26 (YEL/WHT) for VLF, T-80-15 (RED/WHT) for AM BCB and low medium wave, either T-80-2 (RED) or T-80-6 (YEL) for medium wave to shortwave, and T-80-12 (GRN/WHT) for VHF. Again, their -50 and -68 equivalents are also usable. Some experimentation might be needed in specific cases depending on the local noise problem.

Figure 7 shows a version of the noise cancellation bridge circuit made popular by William Orr (W6SAI) and William R. Nelson (WA6FQG) for amateur radio use (*Interference Handbook*, RAC Publications, P.O. Box 2013, Lakewood, NJ 08701). It is built on the same principles as Figure 4, but includes an L-C phase shift network consisting of L1, C1, and C2. The values are:

- T1: 16 turns, #18 AWG trifilar wound on Amidon
- FT-82-61 core
- T2: 18 turns, #18 AWG, bifilar wound on Amidon
- FT-82-61 core
- L1: 32 uH, 45 turns, #22 enameled wire, 1-inch diameter, wire-diameter spaced
- R1,R2: 500-ohms, non-inductive linear taper potentiometer
- C1,C2: 365 pF capacitors

The coil L1 should be wound with either enameled wire or non-insulated solid wire so that it can be tapped.

To adjust this bridge, C1, C2, and the tape on L1 should be adjusted iteratively until the lowest possible noise signal is achieved. To do this trick, it is usually necessary to set R1 and R2 to a low setting, but not so low that both the noise and the signal disappear.

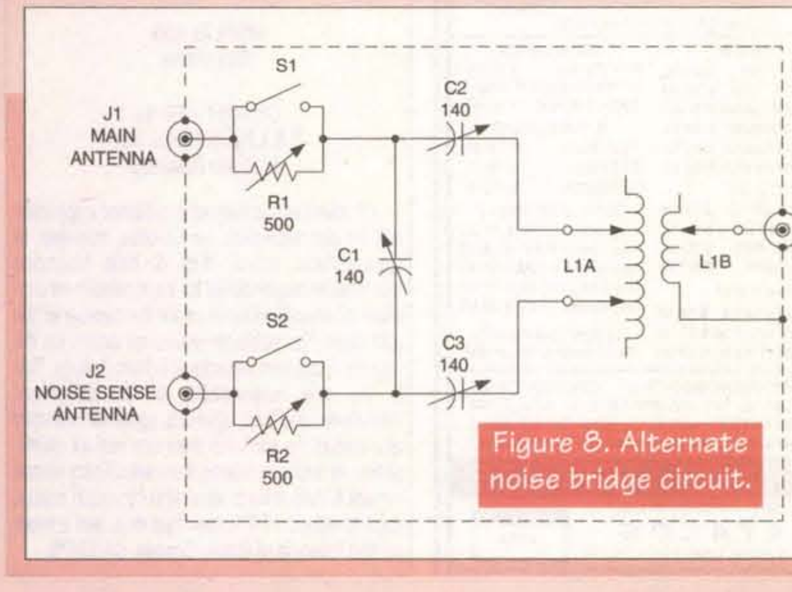

Figure 8. Alternate noise bridge circuit.

A Different Bridge

A somewhat different approach to the bridge concept is shown in Figure 8.

L1A: 12 turns #22 AWG solid bare wire, one-inch diameter, wound over two-inches length.

L1B: Five turns spaced one diameter apart, #22 AWG solid bare wire, wound over center of L1A (a layer of insulating black electrical tape must separate the two coils).

The potentiometers are 500-ohm, linear tape, non-inductive pots of the type also specified for Figure 4. This bridge is tricky to balance as it involves the interaction of R1, R2, C1, C2, C3, L1A, and L1B. In some cases, one or both potentiometers must be shorted out to allow signal to pass unimpeded. In other cases, some value of R1 or R2 may be needed to balance amplitudes. Adjust all components iteratively until the best signal-to-noise ratio is obtained.

Parts can be a little difficult to obtain for RF projects, especially the capacitors. Ocean State Electronics [6 Industrial Drive, P.O. Box 1458, Westerly, RI 02891; 401-596-3080 or FAX 401-596-3590] stocks both new and used variable capacitors, as well as various inductors, toroid cores, and other items of interest.

Conclusion

Radiated noise can be one of the most intractable electromagnetic interference (EMI) problems. These bridges are not a "silver bullet" by any means, but they will perform sufficient noise reduction to make a significant difference in the signal-to-noise ratio ... and that's what actually counts. **NV**

Connections ...

I can be reached by snail mail at P.O. Box 1099, Falls Church, VA 22041, or via E-Mail at CARRJJ@AOL.COM.

Newsbytes

Wired Magazine Transports Readers Directly From Printed Page to the Web Via Digimarc Technology In July Issue

Digimarc Corporation (Nasdaq:DMRC), the world leader in digital watermark technology and applications, announced today that *Wired Magazine* will be the first publication to use its new product to bridge print magazine advertisements to relevant information on the Internet.

Digimarc MediaBridge will debut in the July issue of *Wired Magazine* scheduled to go on sale at newsstands on June 13. Advertisements in *Wired Magazine* featuring a Digimarc symbol in the lower outside page corner will be Internet-enabled, meaning they will contain an imperceptible code which when held up to an image-capture device such as a PC camera, will launch a browser and instantly connect readers to a dedicated URL.

"This technology will forever change how we interact with magazines," said Drew Schutte, publisher of *Wired Magazine*. "The Digimarc system dramatically enhances the value of magazine content, improving its relevance to the digital economy."

Digimarc's system embeds an imperceptible code, known as a "digital watermark," in magazine page images during pre-press using standard image-editing software. Without the use of search engines, directories, or portals, consumers can simply hold the magazine page in front of a PC camera and be taken directly to opportunities to purchase online, participate in promotions, or view multimedia presentations.

"This system moves the magazine industry to the forefront of the Internet revolution, benefiting publishers, advertisers, and consumers," said Digimarc CEO Bruce Davis. "Even though magazines are one of the most prominently cited reasons to go on the Internet, they have been forced to deliver this inspiration indirectly, mainly through unrelated portals, directories, and search engines. With Digimarc MediaBridge, magazines will give rise to billions of new direct access points to relevant information and purchase opportunities on the Internet. The magazine publishing industry will become one of the primary means of access and navigation."

Digimarc MediaBridge applications are the latest example of the company's expertise in digital watermark technology.

Launch of Deep Ocean Odyssey to Bring Never-Before-Seen Footage of Deep Ocean

Braving the planet's last uncharted frontier, Deep Ocean Odyssey yesterday announced its formation as an action-adventure, digital media, and exploration company.

In the spirit of Jules Verne's fictitious adventures, or of Jacques Cousteau — the father of scuba — Deep Ocean Odyssey will use two state-of-the-art manned submersibles to explore the secrets of the deep ocean.

Free floating and highly mobile, the Deep Rovers possess unique performance specs, diving exceptionally deep while providing their two-man crews with breathtaking 360-degree views.

With these craft, Deep Ocean Odyssey will explore more of the unknown ocean than any other manned ocean exploration venture in history, bringing the mysteries and majesty of the deep into the theaters, museums, and living rooms of the world.

As part of its mission to bring the deep ocean to a new generation and re-ignite the enthusiasm that greeted the original Jacques Cousteau specials, Deep Ocean Odyssey has agreements to produce large-screen underwater IMAX adventure films, and to broadcast on NBC Sports six hours of action-adventure television programming. The first three hours are slated for January/February 2001.

In order to descend three-quarters of a mile below the ocean's surface, Deep Ocean Odyssey has secured exclusive rights to the two most advanced deep-diving manned submarines in the world: the Deep Rovers. These awesome film-making shuttlecraft, vastly superior to any other manned submersibles, provide a quantum leap in exploration. Compared to a scuba film team, the Deep Rovers can go 10 times deeper, provide 50 times more light, carry five times as many cameras, and stay submerged 10 times longer.

And compared to the half dozen submersibles in the world with the capability of diving deeper — which consist of metal spheres with small portholes to peer through — the two Rovers provide an incomparable 360-degree panoramic vista of the underwater world to Deep Ocean Odyssey's cameras and crews.

With a maximum depth of 3,300 feet, the Deep Rovers are capable of exploring over 40% of the ocean (compared to 1% for a scuba diver), and literally shine a spotlight on a world that has been dark since the dawn of time.

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reader FeedBack

Dear Nuts & Volts:

I received the April issue of *Nuts & Volts* and read Jon William's article. It was great! I have been looking to do something similar and this is a great starting point.

I do have a simple question. What is a 7805 (I'm new to electronics, so this may be a "dumb" question). You show one in Figure 1 of the D/A amplifier circuit, but I see no mention of it in the article.

Rich
via Internet

Response:

Thanks for your note. I am pleased that you enjoyed the article and found it useful. Keep in mind that you can get all the parts from Parallax.

The 7805 is a three-terminal voltage regulator. It will take anything from about six volts to about 25 volts (much higher and it will get too hot) and regulates it down to the five volts needed by the circuit.

Yes, the Stamp has a built-in regulator, but it cannot provide enough current to run the modem. The 7805 can provide 500 mA without a heatsink — plenty to run the Stamp, the modem, and the other circuitry.

Jon Williams
Dallas, TX

Write in 152 on Reader Service Card.

by Steve Daniels

A PC-Board Cutting Jig For The Dremel Tool

Like many hobbyists, I can't live without my Dremel tool and I'm always finding new uses for the tool and its many accessories. I recently bought the No. 212 drill press attachment (see Figure 1), so that I could more accurately drill holes in my PC boards. Having assembled the drill press, I looked at its nice, flat, pre-machined base and got another idea: cutting PC board accurately has always been a chore; why not make a simple jig that would hold a piece of PC board — or other thin sheet stock — vertical, and let me cut or trim it by sliding it past a cutoff wheel?

Figure 1. The Dremel drill press attachment. It has a holder for the rotary tool, and a rack-and-pinion gear for precise raising and lowering.

As it turns out, this is both perfectly feasible and inexpensive. For less than $15.00 in materials, I built an accessory (see Figure 2) that lets me do many jobs that would otherwise require an expensive table saw. Small pieces of epoxy-glass or phenolic board can be cut right on this jig, or you can use the jig to trim slightly ragged edges from pieces cut with a nibbling tool. This article shows what I came up with, how to build it, and how to use it.

A Base For The Drill Press

Some people mount the drill press right on a workbench using the self-tapping screws and washers that come in the box. Since I don't have a lot of bench space, the first thing I wanted was a convenient, tabletop base that would let me disassemble everything for storage. The particle board base that you see in Figure 2 measures 14" x 17". Nothing magic about this size; it was what I had available. Figure 3 shows the pattern of mounting holes that I set up. If you need a base like this, you can either draw the pattern directly on the board with a carpenter's square and mark the hole centers, or create a template as I did using Visio, PowerPoint, or a bitmap editor.

Drill the holes with a 3/8" bit, and carefully hammer in place three 5/16" tee nuts (Figure 4). The drill press now screws on to the base with 5/16" carriage bolts and washers as you saw in Figure 2.

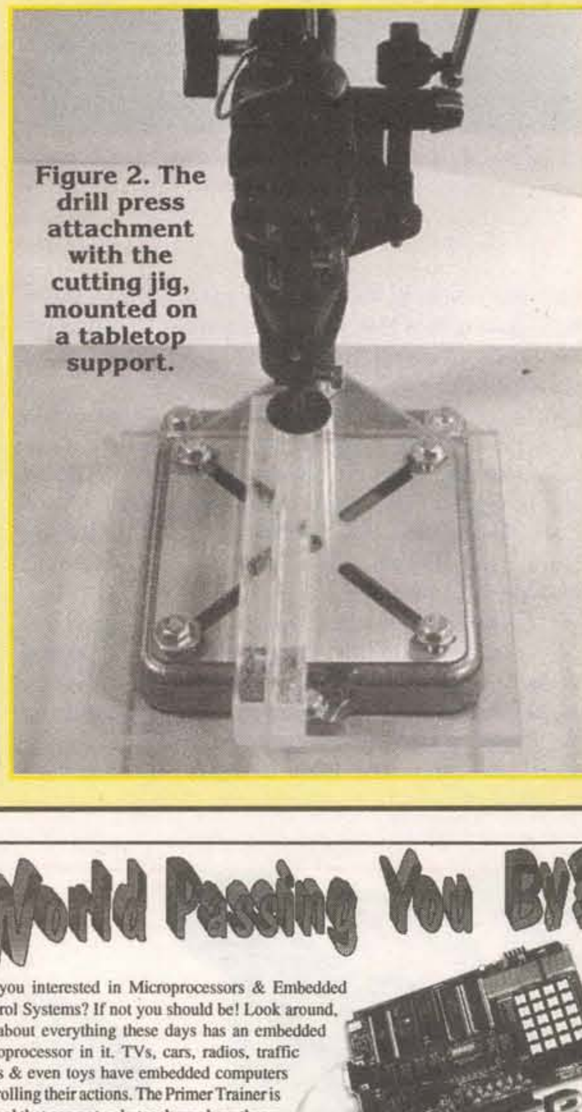


Figure 2. The drill press attachment with the cutting jig, mounted on a tabletop support.

"Hold-Downs" For The Jig

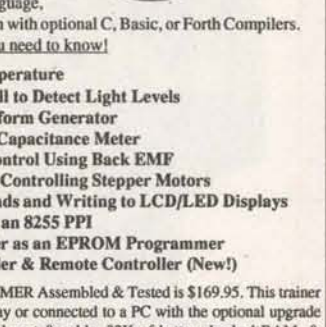
Just as I wanted to be able to take the drill press off the base, I wanted to be able to remove the cutoff jig quickly. My solution was to create four "hold-downs" and fasten one in each corner of the drill press base using epoxy cement.

Each hold-down is a 5/16" washer to which I sweat-soldered a 5/16" nut. To make one of these, start by cleaning the surfaces of the washer and nut with 220 grit sandpaper where the solder will join them. This could also be done with the Dremel tool and a sanding disk. Clean up the residue with acetone. Then assemble a screw, washer, and nut finger-tight, with the nut carefully centered on the washer (Figure 5). Clamp this assembly in a vise as shown in Figure 6.

Figure 3. Pattern for the mounting holes.

To solder a relatively large piece – especially one that will be subjected to mechanical stress – it's best to use a small torch with plumbing-type solder and a paste flux. Apply a small amount of the flux all the way around the area where the edge of the nut meets the washer (Figure 7). With the torch, heat the washer until the flux bubbles vigorously, and then apply a bit of solder (Figure 8). It should flow easily all the way around. The result should look like Figure 9. Extinguish the torch and let the work cool thoroughly before you do anything else.

Paste fluxes are petroleum-based, and they leave an oily residue. Unscrew your newly created hold-down, and clean it thoroughly with mineral spirits or paint thinner,



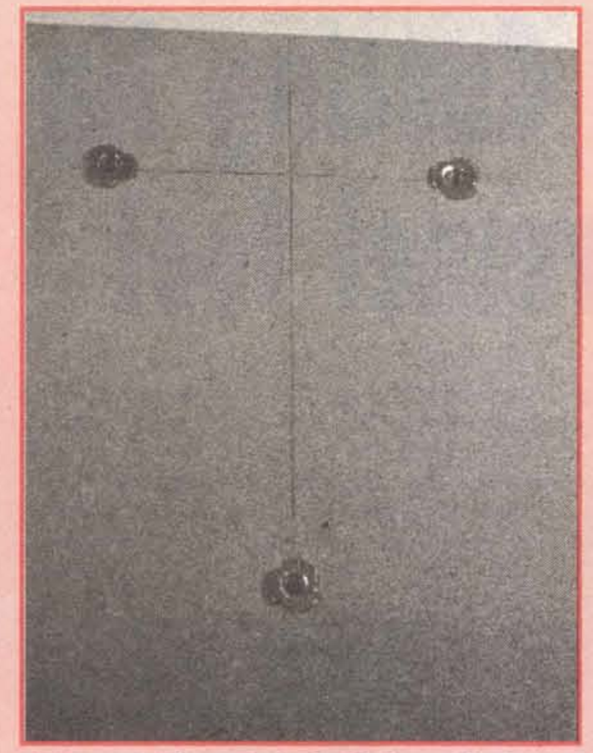


Figure 4. Tee nuts to hold down the base of the drill press.

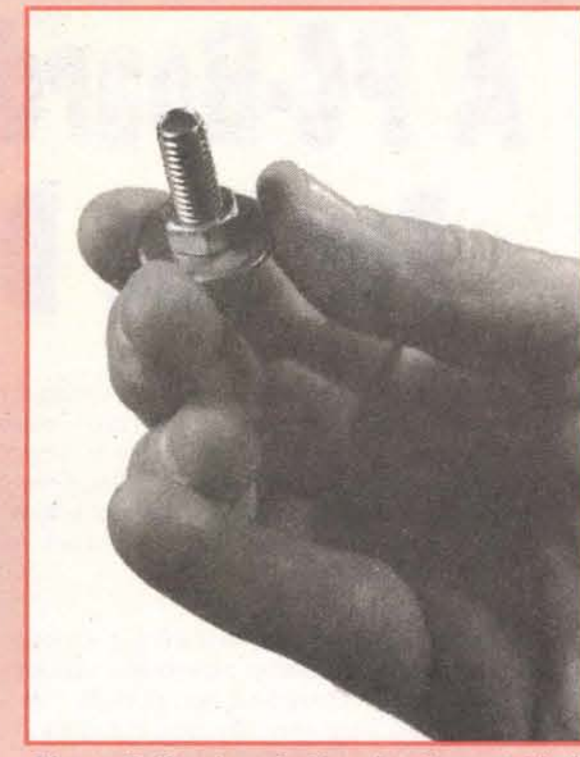


Figure 5. Carriage bolt and nut assembled for soldering.

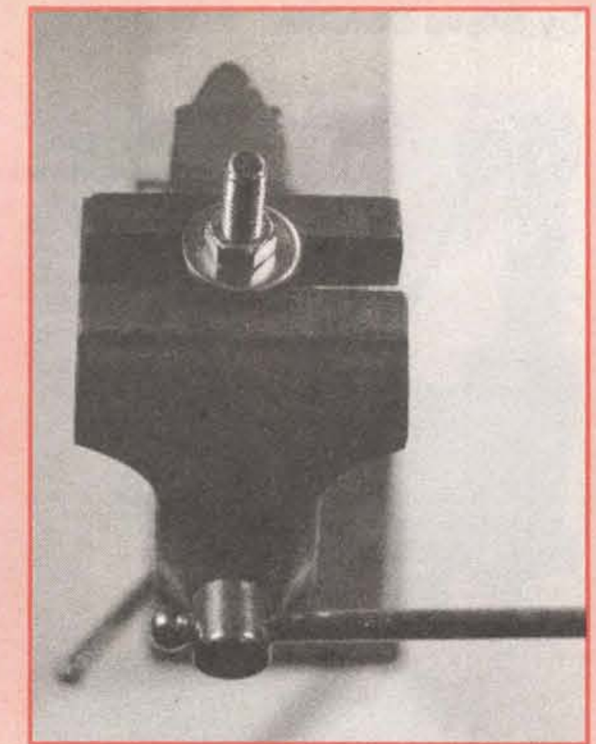


Figure 6. Clamped in vise and ready to solder.

and then with acetone. Then create three more hold-downs like this one. Remember to close up the solvent containers and put them away before you light the torch again!

Once you have four hold-downs, prepare the underside of the base of the drill press by carefully sanding in each corner where a hold-down will be glued. The hand-held Dremel tool with a Carbide sanding disk works fine for this job as shown in Figure 10. Clean up the sanding residue with acetone.

Using quick-setting epoxy cement, glue the hold-downs in place one-at-a-time. I oriented them by eyeball, with the upper corners of each square cutout in the drill press base just touching the radius of the washer. See Figure 11. Once the glue has cured, the base is ready to accept an attachment. See Figure 12.

I chose to use Lucite to make the jig, because it won't distort and is relatively easy to work with hand tools. The base in the photos is an eight-inch-square piece of 3/8" thick material, which I found at the place where I shop on New York's Canal Street; they had a shelf full of small remnants, and I found one of that size and thickness. The base can be a little larger than eight inches square without being unwieldy, so don't be afraid to buy a loose piece of material that is "about right," rather than paying to have the store cut something from a large sheet. The only other requirement is that the edges be straight and the corners be good 90 degree angles; have a small carpenter's square with you to verify this. You'll also need two pieces of square or rectangular stock (mine were 9/16" x 1" rectangular) for the guides, and a tube of thickened acrylic cement. Have the guides cut to exactly the length of the base, and you'll be able to line them up easily later when gluing.

Remove the protective paper covering from the Lucite, and line up one edge exactly with the top edge of the machined area on the base of the drill press. Center the piece by using a ruler; if it is 8" wide, the left and right edges should each be 1" from the edge of the machined area. See Figure 13.

Being careful not to lose the alignment of the Lucite and the metal base; mark the center of each hold-down on the plastic with a scratch awl or scribe. Look directly down onto each hole as you do this. See Figure 14.

Figure 7. Apply flux.

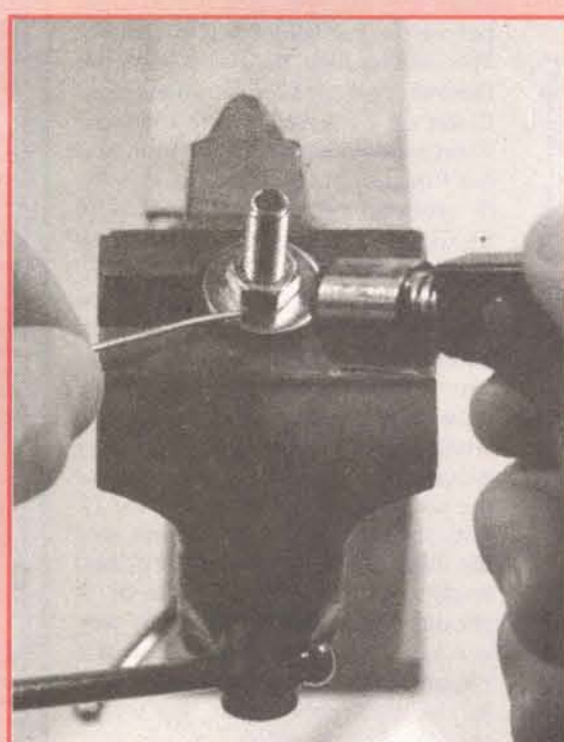


Figure 8. Sweat-soldering.

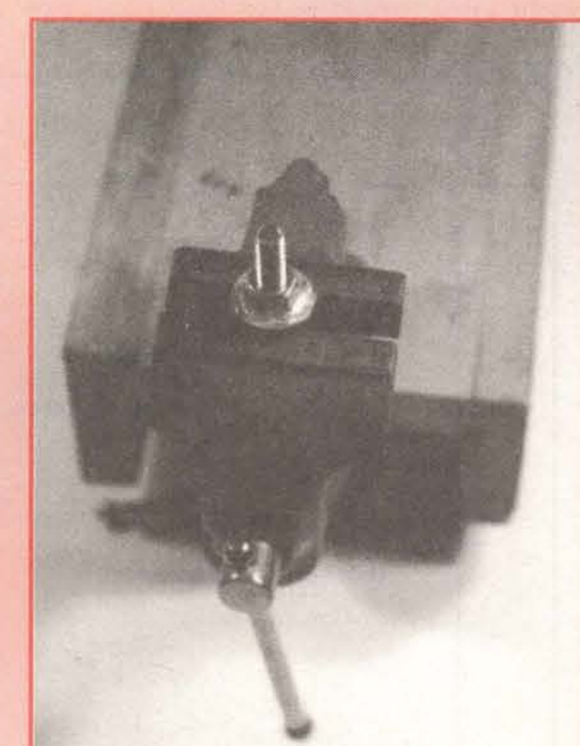


Figure 9. A completed hold-down. Let it cool before you touch it.

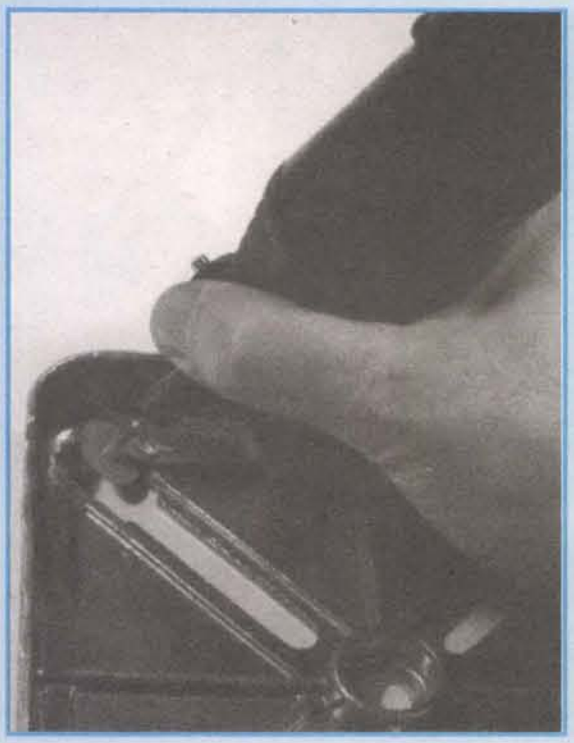


Figure 10. Sand clean the area where the hold-down will be glued.

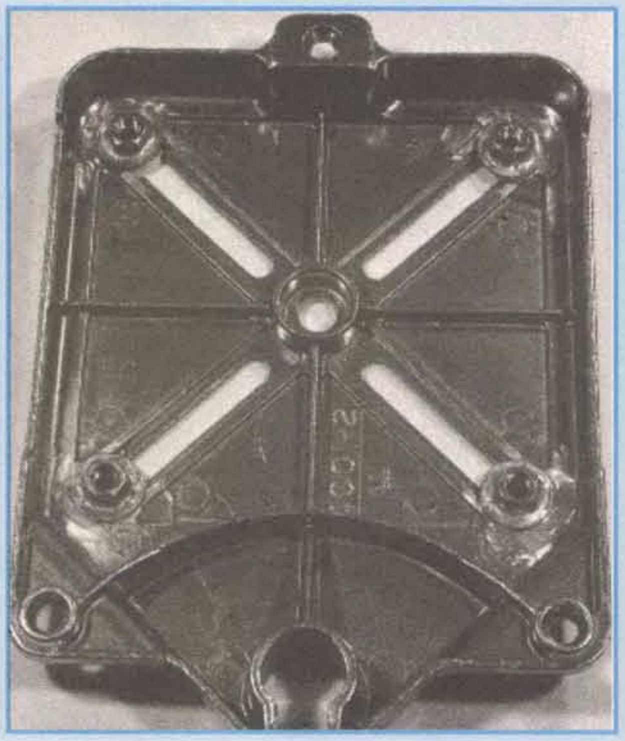


Figure 11. Hold-downs glued in place.

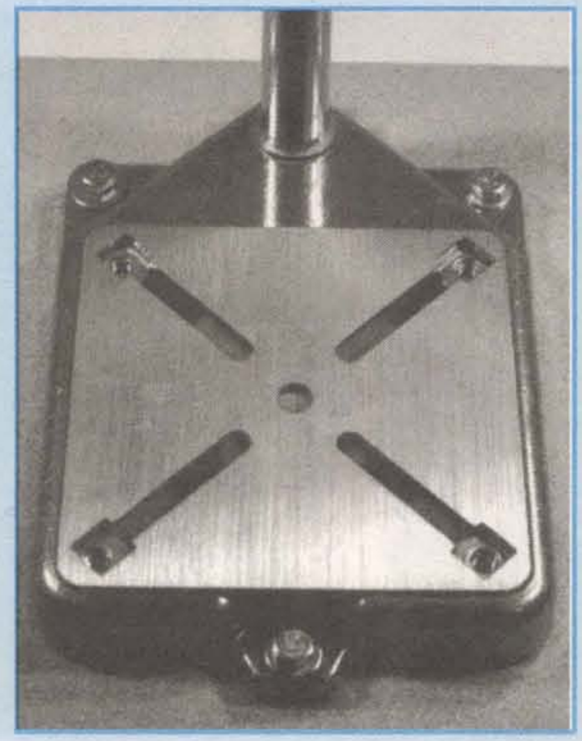


Figure 12. Ready for the jig to be screwed in place.

Drilling large holes in Lucite without cracking it is a matter of starting with a small pilot hole and then following with progressively larger twist drills. I made the pilot hole at each center mark with a 1/8-inch drill and worked up to 5/16" in 1/16" increments. Avoid using a lot of pressure on the tool, work slowly, and hold back to let the twists cut a little at a time — especially with the larger sizes. Once you have all four holes drilled, try screwing the base down and be sure that the screws go accurately into the hold-downs. If your alignment was a little off in drilling the holes, you might be able to recover by using a round file to enlarge one or more of them slightly.

Now to locate where the right-side guide will go. With the Lucite removed, I fastened a piece of masking tape to the base of the drill press, marking a point that would allow about 1/4" between the supporting post and the surface of any sheet material sliding past it. Then I screwed the base securely in place, used a square to define the line I wanted, and marked it with a felt-tip pen. See Figure 15.

The next step is to define with masking tape the area where glue will be applied. Put down one strip of masking tape exactly on the line you just drew and to its left. Place the guide piece down on the base and line up its left edge with the edge of the tape. Put down a second strip of masking tape on the right side of the guide piece. Give some care to getting this piece of tape parallel with the first piece; Figure 16 shows how things should look.

Remove the guide piece and — using 80 or 100 grit sandpaper — gently sand the entire area between the pieces of masking tape. When the whole area is sanded, clean off the residue with a clean, dry cloth. In the same way, sand all over the side of the guide piece that will be glued to the base. See Figure 17 and Figure 18.

You are ready to glue. Apply a thin line of thickened acrylic cement all the way down the middle of the sanded area on the base, and the same on the sanded area of the guide piece. See Figures 19 and 20.

Butt the glued side of the guide piece to the base, and line up its top and bottom edges as carefully as you can with the top and bottom edges of the base. See Figure 21. Let the glue harden for 24 hours before you do anything else, then remove the tape.

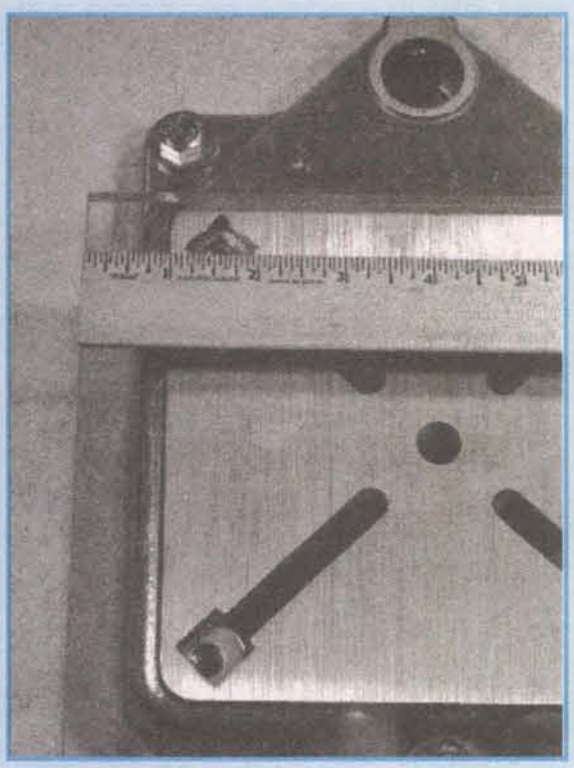


Figure 13. Align the top edge of the Lucite exactly with the top edge of the machined area of the drill press base, and leave equal space on either side.

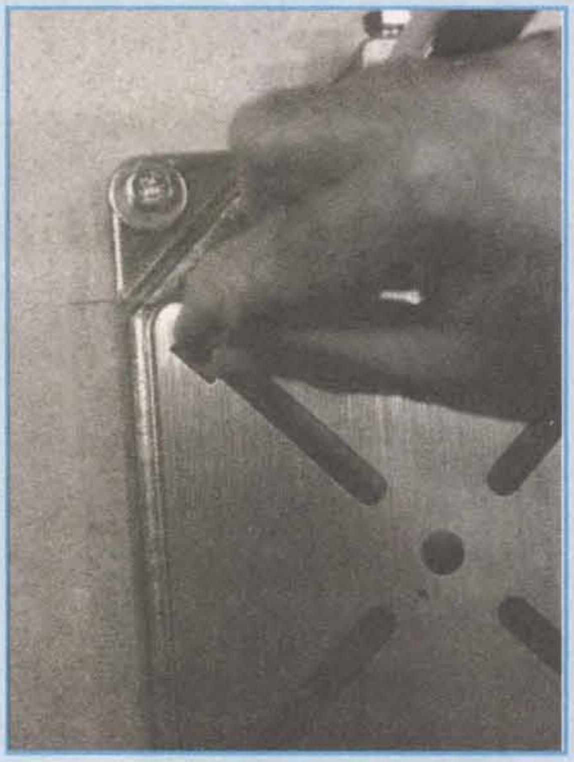


Figure 14. Mark the center points for drilling.

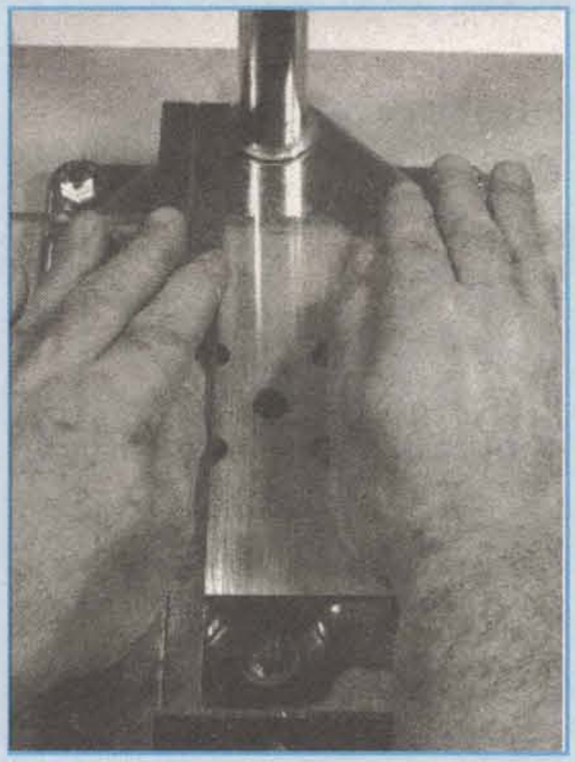


Figure 15. The square defines the line of the inside edge of the right-hand guide. Mark this line with a thin felt-tip marker.

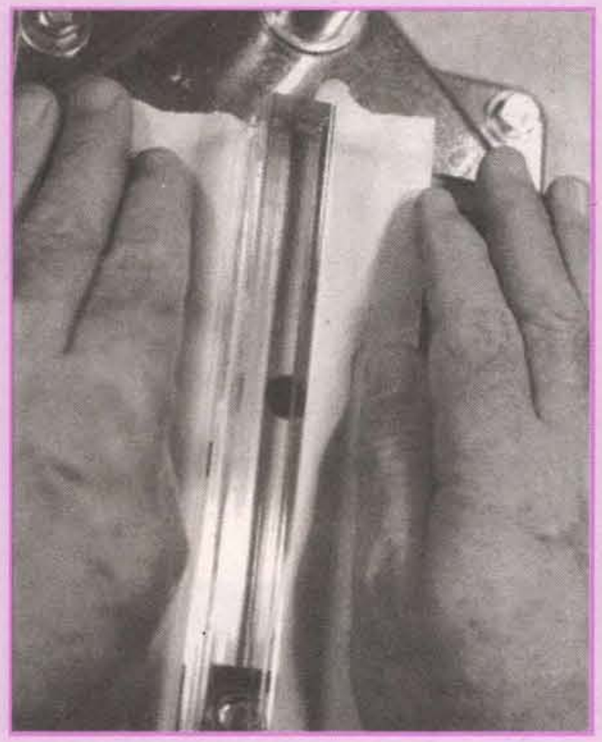


Figure 16. Strips of masking tape define the area to sand for gluing the right-hand guide.

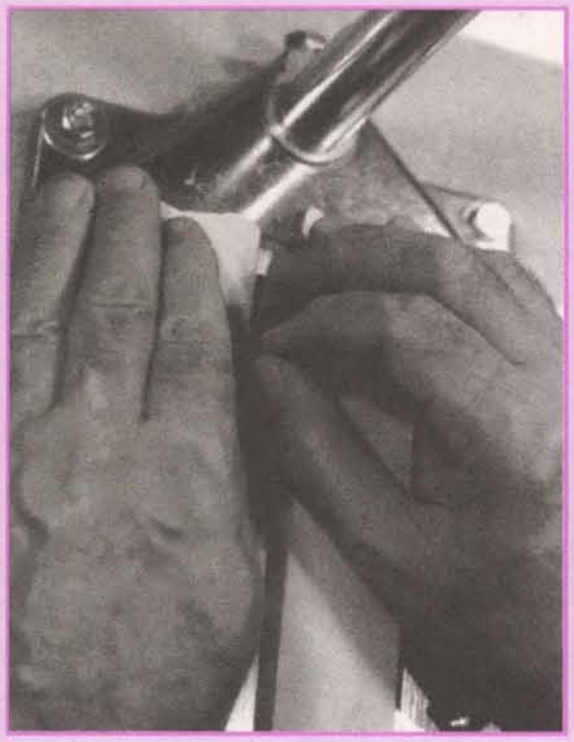


Figure 17. Sand the area between the strips of tape ...

Figure 18. ... and sand the guide piece.

The last step is to establish the position of the left-hand guide, sand the surfaces of the base and the guide as we did before, and glue the left-hand guide in place. Since we are going to be cutting PC board, use a piece to establish the gap between the guides as shown in Figure 22; stand a piece of PC board against the right hand guide and butt the left hand guide against it. Use pieces of masking tape at the top and bottom edges to hold everything stable. Put down a long strip of masking tape to the left of the left-hand guide.

Now remove the left-hand guide, sand the bottom of the guide and the area of the base where it will go down, and clean up as before (Figure 23). Apply glue to the appropriate surfaces. Stand the PC board against the right-hand guide, butt the left-hand guide in place, and line up the upper and lower edges with the edges of the base. Tape the guides together gently and check the alignment again. Things should again look as they do in Figure 22. Let the glue set for 24 hours and then remove the tape.

The jig is ready to use! You may have to run a piece of board through the channel a couple of times to clear out any small amount of glue that remains. Set up the drill press and get ready to work.

How To Use The Jig

Figure 24 shows two standard Dremel cutoff wheels (15/16" No. 409 and 1-1/4" No. 426) that are available for the variable-speed rotary tool No. 395, and the standard mandrel for them, Dremel No. 402. On the right is a 1-1/2" cutoff wheel and larger mandrel that I found at a jewelry tool supplier. More about this one later.

I found that either of the Dremel cutoff wheels will do a perfectly fine job of cutting epoxy-glass board. Screw the wheel onto the mandrel, insert the mandrel into the collet of the tool, and tighten the collet nut in the usual way. Orient the tool holder so that the radius of the cutoff wheel protrudes about 1/8" into the horizontal cutting path established by the guides. Set the height where you need it and tighten the lock knob.

Wear eye protection whenever you are working with the Dremel tool or any rotary cutting tool! Set the tool speed to about 3.5, and feed the board slowly and carefully past the cutoff wheel. Heavy pressure is neither necessary nor desirable. See Figure 25.

What You Can — And Can't — Do

The limit on using this jig to cut large pieces is the distance (1-3/16") between the edge of the wheel when its mandrel is fully inserted in the collet and the lower edge of the tool holder. I have found that I can open this "throat" up by 1/4" without sacrificing stability of the tool by not inserting the shaft of the mandrel fully into the collet as shown in Figure 26.

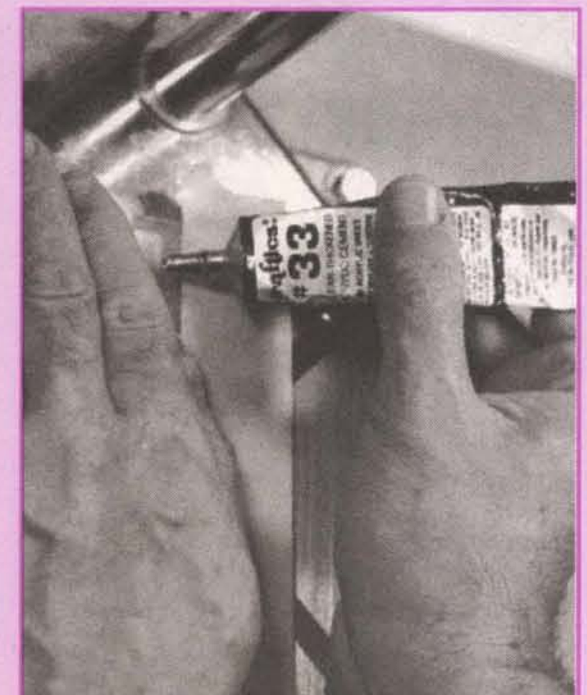


Figure 19. Apply glue on the base ...

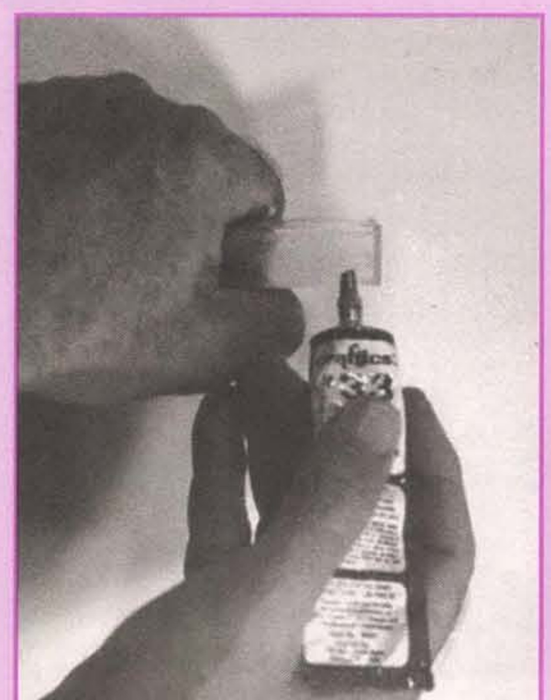


Figure 20. ... and on the guide piece.

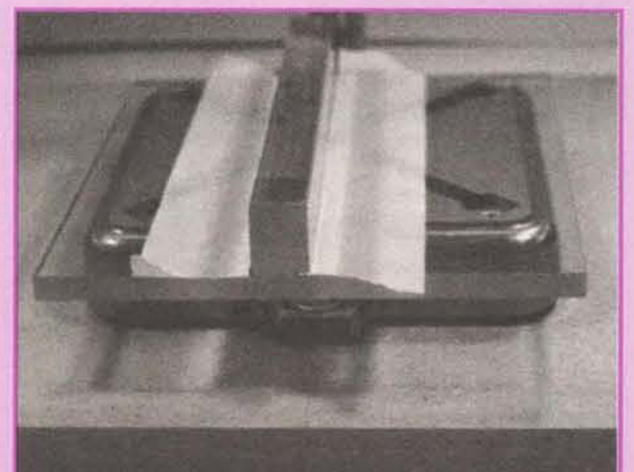


Figure 21. Glue the right-hand guide piece in place. Note that the lower edge is exactly parallel with the edge of the base. Check this alignment on the upper edge as well.

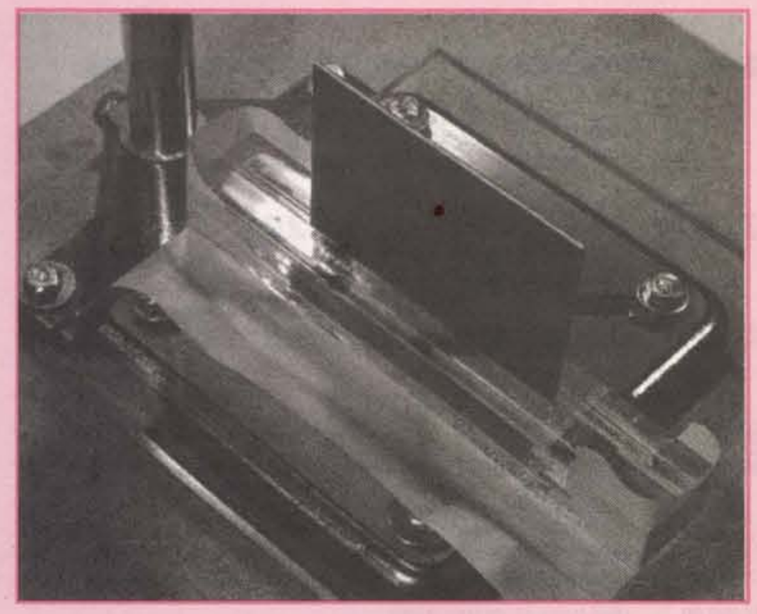


Figure 22. Establish the "channel" through which the board will feed. Doing this also defines the area to sand for gluing the left-hand guide.

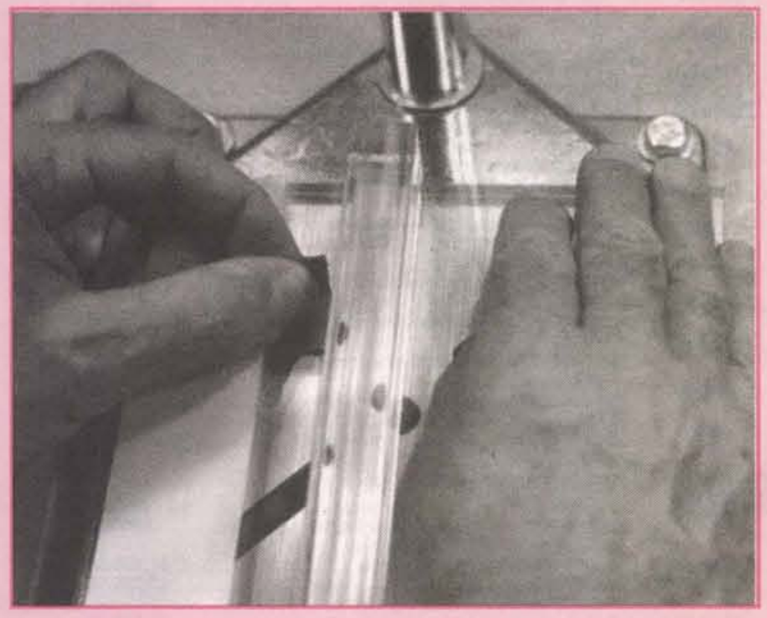


Figure 23. Sand the area where the left-hand guide will go.

It is possible to open the throat still further by using the 1-1/2" cut-off wheel shown in Figure 23. At this diameter, the cutting-edge of the wheel protrudes beyond the radius of the tool holder. Doing this buys about another 3/8" before the top of a piece of board will hit the tool holder (Figure 27). As in Figure 26, I was able to gain still another 1/4" by not inserting the shaft of the mandrel fully into the collet. You can find the 1-1/2" wheel and mandrel at a store that sells equipment and supplies to jewelry makers or dentists. Ask for a Dedeco No. 7002 cutoff wheel and a mandrel for it. To anticipate a question: I saw larger wheels, but I do not recommend trying them in this application; anything larger than 1-1/2" will not be stable at the speeds at which you want to use it for cutting purposes.

If you have to cut a piece that the jig just won't accommodate, mark your pattern on it and cut it roughly to size with a nibbling tool, (which you were probably doing before you built this jig). Now use the jig just to slice off 1/8" or so of ragged edge. As I said in the beginning: It beats paying for a table saw!

Just an aside — the suppliers that have the larger cutoff wheel are fantastic hobbyist's resources for buying high-quality, precision tools and unusual materials. Among other items, I have bought steel "picks," several kinds of precision tweezers and a jeweler's saw — has a bronze blade that is wire-thin for very tight cutting with little loss of material. Get a catalog and/or take some time to shop and browse. If you happen to visit my home town — New York City — check out either Myron Toback or Zak's when you make the obligatory visit to our Diamond District (near Rockefeller Center).

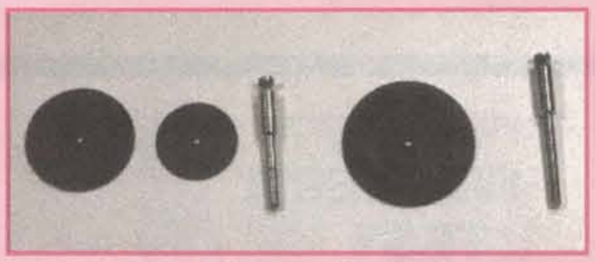


Figure 24. Cutoff wheels.

I hope you find this jig useful, and I welcome questions or comments at smallbearelec@ix.netcom.com. My URL is: http://home.netcom.com/~smallbearelec **NV**

Cutting Jig - Bill Of Materials

Tabletop Base

1	Piece flakeboard or particle board, Roughly 14" x 17"
3	5/16" x 18 threads/in. tee nuts
3	5/16" x 1" x 18 threads/in. carriage bolts
3	5/16" washers

Jig

1	Piece 3/8" thick clear Lucite, roughly 8" square
2	Pieces rectangular or square (1") Lucite stock, cut to length of base piece
4	5/16" x 1" x 18 threads/in. carriage bolts and nuts
8	5/16" washers

Plumbing-type solder (4% silver), paste flux, thickened acrylic cement, masking tape, 80 or 100 grit sandpaper, solvents for cleaning.

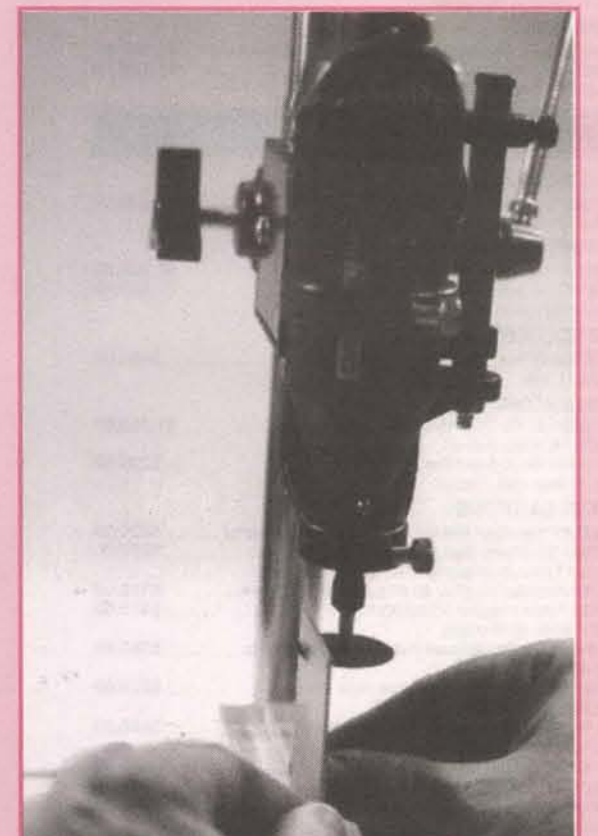


Figure 25. It makes getting a straight edge easy!

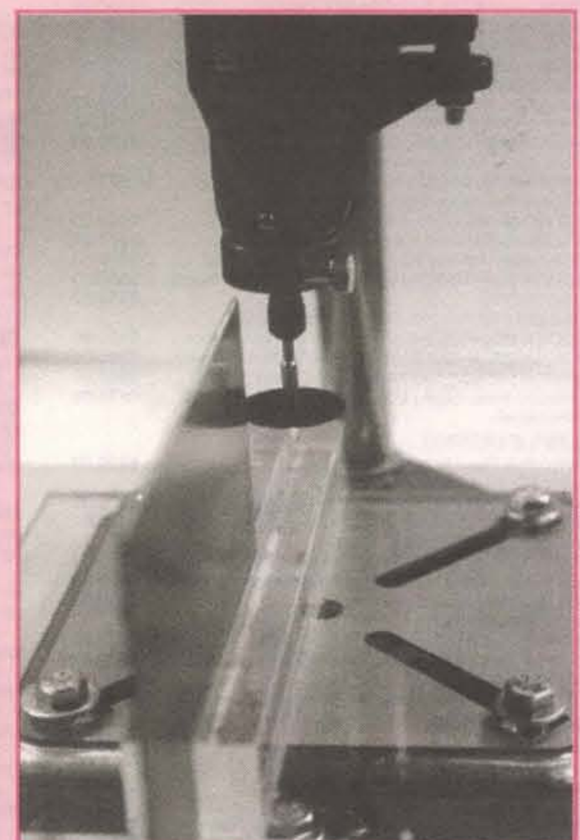


Figure 26. You can get a little more room above the wheel.

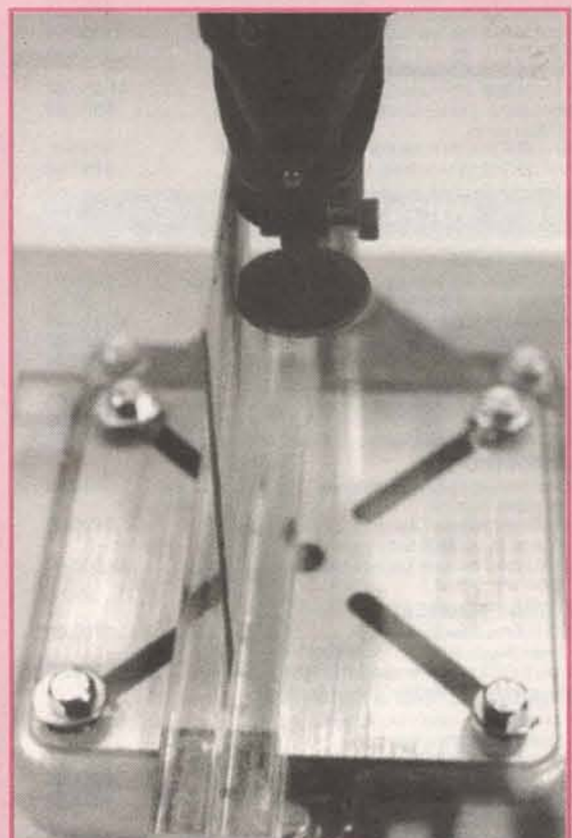


Figure 27. A slightly larger wheel can be used.

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- HP 8660C/86602A/86632B Synth. Sig. Gen., 1-1300 MHz, AM / FM — $2,500.00
- HP 8660C/86603A/86633B Synthesizer, 1-2600 MHz, 1 Hz res., AM / FM — $3,250.00
- HP 8672A Synthesized Signal Generator, 2-18 GHz, +3 dBm output — $4,500.00
- HP 8684B Signal Generator, 5.4-12.5 GHz, AM/ WBFM/ Pulse — $3,000.00

SWEEP GENERATORS

- HP 8340B Synthesized Sweep Generator, 10 MHz-26.5 GHz, AM, FM — $20,000.00
- HP 8350B/83522A Sweep Oscillator, 10-2400 MHz, +13 dBm levelled — $3,900.00
- HP 8350B/83540A-002,004 Sweep Oscillator, 2.0-8.4 GHz, 70 dB step attenuator — $3,900.00
- HP 8350B/83545A-002 Sweep Oscillator, 5.9-12.4 GHz, 70 dB step attenuator — $3,900.00
- HP 8601A Generator/Sweeper, 0.1-110 MHz, +20 dBm levelled — $400.00
- HP 8620C Sweep Oscillator Frame — $550.00
- HP 86222B-E69/8620C Sweep Oscillator, 0.01-2 GHz & 2-4 GHz, +10 dBm — $1,500.00
- HP 86230B RF Plug-in, 1.8-4.2 GHz, +10 dBm unlevelled — $375.00
- HP 86241A-001 RF Plug-in, 3.2-6.5 GHz, +8 dBm levelled — $300.00
- HP 86260A-H04 RF Plug-in, 10.0-15.0 GHz, +10 dBm unlevelled — $500.00
- HP 86290C RF Plug-in, 2.0-18.6 GHz, +13 dBm levelled output — $1,850.00
- WAVETEK 962 Sweep Generator, 1.0-4.0 GHz, markers, +12 dBm unlvld. — $950.00

POWER METERS

- BOONTON 42B/41-4E Analog Power Meter, with 1 MHz-18 GHz sensor — $450.00
- HP 432A/478A Power Meter, -30 to +10 dBm, 10 MHz-10 GHz — $300.00
- HP 435B/8481A Power Meter, -30 to +20 dBm, 10 MHz-18 GHz — $900.00
- HP 435B/8482B Power Meter, 0 to +43 dBm, 100 kHz-4.2 GHz — $1,500.00
- HP 435B/8482H Power Meter, -10 to +34 dBm, 100 kHz-4.2 GHz — $900.00
- HP 436A-022/8481A Power Meter, -30 to +20 dBm, 10 MHz-18 GHz, HPIB — $1,200.00
- HP 436A-022/8484A Power Meter, -70 to -20 dBm, 10 MHz-18 GHz, HPIB — $1,200.00
- HP Q8486A Power Sensor, 33.0-50.0 GHz, WR22, for 435/6/7/8 — $1,200.00
- HP R8486A WR28 Power Sensor, 26.5-40 GHz, for HP 435/6/7/8 — $1,500.00

RF MILLIVOLTMETERS

- RACAL-DANA 9303 RF Millivoltmeter, 10 kHz-2 GHz, -70 to +20 dBm — $750.00

AMPLIFIERS MISCELLANEOUS

- AMPLIFIER RESEARCH 4W1000 Amplifier, 40 dB gain, 4 Watts, 1-1000 MHz — $950.00
- HP 11729B-003 Carrier Noise Test Set, 5 MHz-3.2 GHz — $2,250.00
- HP 415E SWR Meter — $200.00
- HP 8406A Comb Generator, 1/ 10/ 100 MHz increments, to 5 GHz — $500.00
- HP 8447A Amplifier, 20 dB, 0.1-400 MHz, 5 dB NF, +6 dBm output — $375.00
- HP 8447E Amplifier, 22 dB, 0.1-1300 MHz, +13 dBm output — $750.00
- HP 8901A Modulation Analyzer, 150 kHz-1300 MHz — $1,500.00
- HP 8901B-1,2,3 Modulation An., 0.15-1300 MHz, rear input, OCXO, ext.LO — $2,000.00
- HP 8970A Noise Figure Meter — $3,500.00
- HUGHES 1177H10F000 TWT Amplifier, >30 dB gain, 1.4-2.4 GHz, 20 Watts — $2,500.00
- HUGHES 8010H13F000 TWT Amplifier, >30 dB gain, 3-8 GHz, 10 Watts — $2,500.00
- HUGHES 8010H15F000 TWT Amplifier, >30 dB gain, 8-18 GHz, 10 Watts — $3,250.00
- HUGHES 8020H01F000 TWT Amplifier, >30 dB gain, 2-4 GHz, 20 Watts — $4,250.00
- RF POWER LABS ML50 Amplifier, 2-30 MHz, 47 dB gain, 50 Watts, metered, 28V — $350.00
- ROHDE & SCHWARTZ ESH2 Test Receiver, 9 kHz-30 MHz — $3,750.00

COAXIAL & WAVEGUIDE

- AEROWAVE 28-3000/10 WR28 Directional Coupler, 10 dB, 26.5-40 GHz — $300.00
- AMERICAN NUCLEONICS AM-432 Cavity Backed Spiral Antenna,LHC, 2-18 GHz,TNC(f) *NEW* — $95.00
- AVANTEK AMT-400X2 WR28 Active Doubler, +10 dBm in/ +10 dBm out 26-40 GHz — $450.00
- BIRD 6735-300 1 kW Load, 25-1000 MHz, LC(f), with wattmeter — $650.00
- BIRD 8201 500 Watt Oil Dielectric Load, DC-2.5 GHz, N(f) — $350.00
- BIRD 8251 1 kW Oil Dielectric Load, DC-2.4 GHz, N(f) — $500.00
- BIRD 8325-30 30 dB Attenuator, 500 Watts, DC-500 MHz — $400.00
- FXR/MICROLAB S3-02N Triple Stub Tuner, 200-1000 MHz, 100 Watts max., N(m/f) — $125.00
- FXR/MICROLAB SL-03N Stub Stretcher, 0.3-6.0 GHz, 100 Watts max., N(m/f) — $75.00
- GR 874-LTL Constant Impedance Trombone Line, 0-44 cm, DC-2 GHz — $400.00
- HP 11590A-001 Bias Network, 1.0-18.0 GHz, APC7 — $450.00
- HP 11636A 2-Way Power Divider, DC-18 GHz, N(m/f/f) — $300.00
- HP 11691D-001 Directional Coupler, 22 dB, 2-18 GHz, N(f)-all ports — $450.00
- HP 11692D Dual Directional Coupler, 22 dB, 2-18 GHz — $800.00
- HP 33321K Programmable Step Atten., 0-70 dB, DC-26.5 GHz, 3.5mm — $475.00
- HP 33327L-006 Programmable Step Attenuator, 0-70 dB, DC-40 GHz, 2.9mm — $1,000.00
- HP 774D Dual Directional Coupler, 20 dB, 215-450 MHz — $275.00
- HP 776D Dual Directional Coupler, 20 dB, 940-1900 MHz — $275.00
- HP 777D Dual Directional Coupler, 20 dB, 1.9-4.1 GHz — $275.00
- HP 778D-011 Dual Dir. Coupler, 20 dB, 100-2000 MHz, APC7 test port — $450.00
- HP 8431A 2-4 GHz Band Pass Filter, N(m/f) — $150.00
- HP 8472B Crystal Detector, 10 MHz-18 GHz, negative polarity, SMA — $225.00
- HP 8494G-002 Programmable Step Attenuator, 0-11 dB, DC-4 GHz, SMA — $350.00
- HP 8495H-001 Programmable Step Attenuator, 0-70 dB, DC-18 GHz, N — $400.00
- HP 8496A-002 Step Attenuator, 0-110 dB, DC-4 GHz, SMA — $375.00
- HP 8497K-004 Programmable Step Attenuator, 0-90 dB, DC-26.5 GHz — $750.00
- HP K422A WR42 Flat Broadband Detector, 18.0-26.5 GHz — $350.00
- HP K532A WR42 Frequency Meter, 18.0-26.5 GHz — $450.00
- HP K752D WR42 Directional Coupler, 20 dB, 18.0-26.5 GHz — $450.00
- HP K870A WR42 Slide Screw Tuner, 18.0-26.5 GHz — $275.00
- HP K914B WR42 Moving Load, 18.0-26.5 GHz — $300.00
- HP Q752D WR22 Directional Coupler, 20 dB, 33-50 GHz — $650.00
- HP R382A WR28 Direct Reading Attenuator, 0-50 dB, 26.5-40 GHz — $2,250.00
- HP R422A WR28 Crystal Detector, 26.5-40 GHz — $400.00
- HP R752D WR28 Directional Coupler, 20 dB, 26.5-40 GHz — $450.00
- HP R914B WR28 Moving Load, 26.5-40 GHz — $250.00
- HP V365A WR15 Isolator, 25 dB, 50-75 GHz — $750.00
- HP V752D WR15 Directional Coupler, 20 dB, 50-75 GHz — $650.00
- HP X870A WR90 Slide Screw Tuner — $150.00
- HUGHES 45322H-1110/1120 WR22 Directional Couplers, 10 or 20 dB, 33-50 GHz — $350.00
- HUGHES 45712H-1000 WR22 Frequency Meter, 33-50 GHz — $750.00
- HUGHES 45714H-1000 WR15 Frequency Meter, 50-75 GHz — $900.00
- HUGHES 45721H-2000 WR28 Direct Reading Attenuator, 0-50 dB, 26.5-40 GHz — $1,000.00
- HUGHES 45722H-1000 WR22 Direct Reading Attenuator, 0-50 dB, 33-50 GHz — $1,000.00
- HUGHES 45724H-1000 WR15 Direct Reading Attenuator, 0-50 dB, 50-75 GHz — $1,000.00
- HUGHES 45732H-1200 WR22 Level Set Attenuator, 0-25 dB, 33-50 GHz — $250.00
- HUGHES 45752H-1000 WR22 Direct Reading Phase Shifter, 0-360 deg.,33-50 GHz — $1,400.00
- HUGHES 45772H-1100 WR22 Thermistor Mount, -20 to +10 dBm, 33-50 GHz — $400.00
- HUGHES 45773H-1100 WR19 Thermistor Mount, -20 to +10 dBm, 40-60 GHz — $650.00
- HUGHES 45774H-1100 WR15 Thermistor Mount, -20 to +10 dBm, 50-75 GHz — $750.00
- HUGHES 47316H-1111 WR10 Tuneable Detector, 75-110 GHz, positive polarity — $600.00
- HUGHES 47741H-2310 WR28 Phase Locked Gunn Osc., 32.000 GHz, +18 dBm — $2,000.00
- HUGHES 47742H-1210 WR22 Phase Locked Gunn Osc., 42.000 GHz, +18 dBm — $2,750.00
- KRYTAR 201020010 Directional Detector, 1-20 GHz, SMA(f/f)/SMC — $200.00
- KRYTAR 2616S Directional Detector, 1.7-26.5 GHz, K(f/m)/SMC — $200.00
- M/A-COM 3-19-300/10 WR19 Directional Coupler, 10 dB, 40-60 GHz — $450.00
- MICA C-121S06 Circulator, 17.5-24.5 GHz, SMA(f/m/m) — $75.00
- MINI-CIRCUITS ZFDC-20-4 Directional Coupler, 19.5 dB, 1-1000 MHz, SMA(f) — $25.00
- NARDA 3000-SERIES Directional Couplers — $150.00
- NARDA 3020A Bi-Directional Coupler, 50-1000 MHz, N — $475.00
- NARDA 3024 Bi-Directional Coupler, 20 dB, 4-8 GHz — $375.00
- NARDA 3090-SERIES Precision High Directivity Couplers — $225.00
- NARDA 368BNM Coaxial High Power Load, 500 Watts, 2.0-18 GHz, N(m) — $500.00
- NARDA 3752 Coaxial Phase Shifter, 0-180 deg./GHz, 1-5 GHz — $1,000.00
- NARDA 3753B Coaxial Phase Shifter, 0-55 deg./GHz, 3.5-12.4 GHz — $1,000.00
- NARDA 4000-SERIES SMA Miniature Directional Couplers — $75.00
- NARDA 4226-10 Directional Coupler, 10 dB, 0.5-18.0 GHz, SMA(f) — $275.00
- NARDA 4227-16 Directional Coupler, 16 dB, 1.7-26.5 GHz, 3.5mm(f) — $325.00
- NARDA 4242-20 Directional Coupler, 20 dB, 0.5-2.0 GHz, SMA(f) — $100.00
- NARDA 4247-20 Directional Coupler, 20 dB, 6.0-26.5 GHz, 3.5mm(f) — $200.00
- NARDA 4247B-10 Directional Coupler, 10 dB, 6.0-26.5 GHz, 3.5mm(f) — $200.00
- NARDA 5070-SERIES Precision Reflectometer Couplers — $300.00
- NARDA 562 DC Block, 10 MHz-12.4 GHz, 100 V max., N(m/f) — $65.00
- NARDA 765-10 10 dB Attenuator, 50 Watts, DC-5 GHz, N(m/f) — $165.00
- NARDA 791FM Variable Attenuator, 0-37 dB, 2.0-12.4 GHz — $600.00
- NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz — $375.00
- NARDA 794FM Direct Reading Variable Attenuator, 0-40 dB, 4-8 GHz — $375.00
- OMNI-SPECTRA 2085-6010-00 Crystal Detector, 1-18 GHz, negative polarity, SMA(m/f) — $50.00
- PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz — $250.00
- SONOMA SCIENTIFIC 21A3 WR42 Circulator, 20 dB, 20.6-24.8 GHz — $75.00
- TEKTRONIX 2701 Step Attenuator, 0-79 dB, DC-1 GHz, AC or DC coupled — $175.00
- TRG B510 WR22 Direct Reading Attenuator, 0-50 dB, 33-50 GHz — $900.00
- TRG V510 WR15 Direct Reading Attenuator, 0-50 dB, 50-75 GHz — $900.00
- TRG V551 WR15 Frequency Meter, 50-75 GHz — $600.00
- TRG W510 WR10 Direct Reading Attenuator, 0-50 dB, 75-110 GHz — $1,000.00
- TRG W551 WR10 Frequency Meter, 75-110 GHz — $750.00
- WAVELINE 100080 WR28 Terminated Crossguide Coupler, 30 dB — $200.00
- WEINSCHEL 150-110 Programmable Step Attenuator, 0-110 dB, DC-18 GHz, SMA — $450.00
- WEINSCHEL DS109 Double Stub Tuner, 1-13 GHz, N(m/f) — $150.00
- WEINSCHEL DS109LL Double Stub Tuner, 0.2-2.0 GHz, N(m/f) — $150.00

COMMUNICATIONS

- HP 3780A-001 Pattern Generator / Error Detector, 1 kb/s - 50 Mb/s — $1,000.00
- HP 4935A Transmission Impairment Measuring Set — $600.00
- HP 59401A HPIB Bus Analyzer — $375.00
- MICRODYNE 1200MR 215-320 MHz Telemetry Receiver, PSK demodulation — $600.00
- TEK 1410R NTSC Gen., w/SPG2 sync. generator, TSG7 color bars — $800.00
- TEK 1411R PAL Gen.,w/SPG12 sync;TSG11 color bars; TSG13 linearity — $750.00
- TEK 1411R PAL Test Gen., w/SPG12,TSG11,TSG13, TSG15,TSG16 — $1,000.00
- TEK 1411R PAL Test Gen., w/SPG12,TSG11,TSG12, TSG13,TSG15,TSG16 — $1,100.00
- TEK 1411R-opt.04 PAL Test Gen.,w/SPG12,TSG11, TSP11,TSG13,TSG15,TSG16 — $1,400.00
- TEK 147A NTSC Test Signal Generator, with noise test signal — $800.00
- TEK 148 PAL Insertion Test Signal Generator — $700.00
- TEK 520A NTSC Vectorscope — $750.00
- TEK 521A PAL Vectorscope — $750.00

MISCELLANEOUS

- FLUKE 2180A RTD Digital Thermometer — $500.00
- HP 7090A Measurement Plotting System — $1,200.00
- P.A.R. 5206-95,98 Two-Phase Lock-in Amp., 2 Hz-100 kHz, GPIB — $1,500.00
- TEK TM5003 5000-series 3-slot Programmable Power Module — $450.00
- TEK TM5006 5000-series 6-slot Programmable Power Module — $500.00
- TEK TM504 500-series 4-slot Power Module — $175.00
- TEK TM506 500-series 6-slot Power Module — $250.00
- TEK TM515 500-series 5-slot Traveller Power Module — $250.00

Write in 153 on Reader Service Card.

Events CALENDAR

The Events Calendar is a free service for publicizing electronic events such as amateur radio hamfests, flea markets, etc. If your organization is sponsoring an event and would like a free listing, contact us at least 60 days in advance. Include your flyer, estimated attendance, name of the person to contact, and phone number.

Complimentary issues are available upon request for distribution to your attendees. A street address for UPS is required.

While we strive for accuracy in our calendar, we can not be responsible for errors or cancellations. The information contained in this column is for the use of the readers of *Nuts & Volts* and may not be republished in any form without the written permission of T & L Publications, Inc.

All listing information should be sent to:
Nuts & Volts Magazine
Events Calendar
430 Princeland Court
Corona, CA 92879
Phone 909-371-8497
Fax 909-371-3052
E-mail events@nutsvolts.com

JUNE 2000

JUNE 2-3

GA - MARIETTA - Convention. Jim Miller Park. Fri: 3pm-6:30pm, Sat: 8:30am-3pm. VEC testing. Talk-in: 148.82-. Atlanta RC, Ben Dasher KE4YZX, 404-869-6959.
E-Mail: bendasher@mindspring.com
Web: http://www.saf.com/arc/

NE - SOUTH SIOUX CITY - Midwest/Dakota Convention. 3900 Club & Sooland ARA, Leroy Baldwin W0OFY, 319-395-7183.
E-Mail: lgbw0ofy@aol.com

JUNE 2-3-4

NY - ROCHESTER - Convention. Monroe County Fairgrounds, Rt. 15A. Fri: 12pm-5:30pm, Sat: 8:30am-5:30pm, Sun: 8:30am-1:30pm. Harold Smith K2HC, 716-424-7184.
E-Mail: rochfst@frontiernet.net
Web: http://www.rochesterhamfest.org

JUNE 3

IL - SPRINGFIELD - Hamfest. State Fairgrounds, Gate 11. VE Testing. Talk-in: 146.685-. Sangamon Valley RC, Edmund Gaffney KA9ETP, 217-628-3697. E-Mail: egaffney@family-net.net
Web: http://www.w9dua.net

ME - HERMON - Hamfest. Pine State ARC, Edward Richardson K1DTW, 207-825-4417.
E-Mail: edandglo@earthlink.net

MI - GRAND RAPIDS - Hamfest. Hudsonville Fairgrounds. VE Testing. Talk-in: 147.16. Independent Repeater Assn., Kathy KB8KZH, 616-698-6627 between 4-7pm Eastern.
Web: http://www.iserv.net/~w8hvg

NJ - TEANECK - Hamfest. Fairleigh Dickinson University. 8am-2pm. Talk-in: 146.19/79. Bergen ARA, James Joyce K2ZO, 201-664-6725. E-Mail: hamfest@bara.org Web: http://www/bara.org

JUNE 3-4

NE - CHADRON - Hamfest. Pine Ridge ARC, Phil Cary WA0PZA, 308-432-3956.
E-Mail: philcary@bbc.net

OR - SEASIDE - Northwestern Division ARRL Convention. Convention Center. VE testing. Talk-in: 146.660 (-600). SEAPAC, Randy Stimson KZ7T, 503-297-1175. Web: www.seapac.org

JUNE 4

CT - NEWINGTON - Hamfest. Newington High School, Willard Ave. (Rt. 173). 9am-1pm. FCC exams. Talk-in: 145.45, 146.52 simplex, 224.84, 443.05. Newington Amateur Radio League, Inc., Thomas Ponte WB1CZX, 860-666-4539.
E-Mail: wb1czx@arrl.net

IL - PRINCETON - Hamfest. Bureau County Fairgrounds. Talk-in: 146.955 -600 PL 103.5. Starved Rock Radio Club, Alan Erbrederis N9PIB, 815-498-9675. E-Mail: erb.n9pib@junol.com
Web: http://www.qsl.net/w9mks/hamfest/htm

NY - QUEENS - Hamfest. NY Hall of Science parking lot, Flushing Meadow Corona Park, 47-01 111th St. VE exams. Talk-in: 444.200 repeat, PL 136.5, 146.52 simplex. The Hall of Science ARC, Stephen Greenbaum WB2KDG, 718-898-5599, eves only. E-Mail: WB2KDG@Bigfoot.com or Andy Borrok N2TZX, 718-291-2561. E-Mail: N2TZX@webspan.net

PA - BUTLER - Hamfest. Butler Farm Show Grounds. 8am-4pm. Talk-in: 147.96/36. Breezeshooters ARC, H. Rey Whanger W3BIS, 412-826-8006. E-Mail: w3bis@breezeshooters.net
Web: http://www.breezeshooters.net

VA - MANASSAS - Hamfest. Prince William County Fairgrounds. Talk-in: 146.97-, 224.660-, 442.200+. Ole Virginia Hams ARC, Jack McDermott N4YIC, 703-335-9139.
E-Mail: N4YIC@arrl.net or patnjack@erols.com
Web: http://www.qsl.net/olevahams/

JUNE 9-10

TX - ARLINGTON - State Convention. HAM-COM, Maury Guzick W5BGP, 214-804-0680.
E-Mail: chairman@hamcom.org
Web: http://www.hamcom.org

JUNE 9-10-11

WA - DRYDEN - Hamfest. Apple City ARC, Roger Eckhardt WB7SHL, 509-782-4977. E-Mail: dmeck hardt@juno.com Web: http://www.qsl.net/w7td

JUNE 10

CA - FONTANA - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves

MA - EAST FALMOUTH - Hamfest. Barnstable County Fairgrounds, Rt. 151. 9am-2pm. VE sessions. Falmouth ARA, Ralph K. Swenson 508-548-6405. E-Mail: DEPSHER911@AOL.COM
Web: http://www.falara.org

MO - MACON - Hamfest. Macon Vo-Tech School. 8am-12pm. FCC Exams. Talk-in: 146.805(-). Macon County ARC, Dale Bagley K0KY, 660-385-3629. E-Mail: n0pr@arrl.net Web: http://www.cyberusa.com/~kfoster/hamfest.htm

NC - WINSTON-SALEM - Hamfest. Forsyth ARC, John Kippe N0KTY, 336-723-7388. Web: http://members.xoom.com/w4nc/hamfest.htm

NY - CORTLAND - Hamfest. Skyline ARC, Andrew Slaugh KB2LUV, 607-753-0597.
E-Mail: kb2luv@clarityconnect.com

PA - BLOOMSBURG - Eastern PA Section Convention. Bloomsburg Fairgrounds. 8am-3pm. VEC Testing. Talk-in: 147.225 (+600) and 146.52 simplex. Columbia-Montour ARC, George Law N3KYZ, 570-784-2299. E-Mail: n3kyz@epix.net
Web: http://www.bafn.org/~cmarc

JUNE 11

IL - WHEATON - Hamfest. DuPage County Fairgrounds, 2015 Manchester Rd. VE testing. Six Meter Club of Chicago, Joseph Gutwein WA9RIJ, 630-963-4922 or 708-442-4961.
E-Mail: wa9rij@mc.net
Web: http://cyberconnect.com/orion/smcc.html

IN - WABASH - Hamfest. County 4-H Fairgrounds, St. Rd. 13N. Talk-in: 147.03/147.63, 442.325/447.325. Wabash County ARC, Inc., Ralph Frank, 219-563-8487 office or 765-833-7372 home. E-Mail: wial@netusal.net

KY - INDEPENDENCE - Hamfest. Northern KY ARC, Robert Blocher N8JMV, 513-797-7252.
E-Mail: nkarc@juno.com

NY - BETHPAGE - Hamfest. Briarcliffe College, 1055 Stewart Ave. 8:30am-1pm. VE testing. Talk-in: W2VL 146.85 repeater (136.5 PL). Long Island Mobile ARC, Ed Muro KC2AYC, 516-520-9311.
E-Mail: hamfest@limarc.org
Web: http://www.limarc.org

OH - CANFIELD - Hamfest. Mahoning County Joint Vocational School, Palmyra Rd. 8am-3pm. Twenty Over Nine ARC, Don Stoddard N8LNE, 330-793-7072. E-Mail: n8lne@juno.com

OH - SUFFIELD - Hamfest. Goodyear ARC, Fred Mealy KC8BQX, 330-665-4563.
E-Mail: fmealy@earthlink.net

TN - KNOXVILLE - Convention. National Guard Armory, 3330 Sutherland Ave. 9am-4pm. VE Exams. Talk-in: 147.30+, 224.50-, 444.575-. RAC of Knoxville, David Bower K4PZT, 865-670-1503.
E-Mail: rack@kornnet.org
Web: http://www.korrnet.org/rack

JUNE 17

CT - GOSHEN - Hamfest. Southern Berkshire ARC, Lee Collins K1LEE, 860-435-0051.
E-Mail: lee@leecollins.com

MI - MIDLAND - Hamfest. Midland County Fairgrounds, Gerstacker Fair Center. 8am-1pm. Talk-in: 147.000+. Midland ARC, Del Lafevor WB8FYR, 517-689-3477.
E-Mail: lafevordel@aol.com
Web: http://www.qsl.net/w8kea/MARCSWAP.htm

MN - ST. PAUL - Hamfest. TwinsLan ARC, Ann Foster N0LLC, 612-706-1761.
E-Mail: tailgate@twinslan.org

MO - HOUSTON - Hamfest. Texas County Fairgrounds. 8am-3pm. Talk-in: 146.850. Ozark Mountain RC, Willy Adey N0TPE, 573-674-2174, E-Mail: n0tpewla@train.missouri.org Blanche White N0FLR, 417-967-3000

NJ - DUNELLEN - Hamfest. Columbia Park. 7am-2pm. Talk-in: 146.025/625, 447.250/442.250, PL 141.3, 146.520 simplex. Raritan Valley Radio Association, Fred Werner KB2HZO, 732-968-7789 before 8pm. E-Mail: wb2njh@aol.com or Doug Benner W2NJH, 732-469-9009.
Web: http://www.w2qw.org

OH - MILFORD - Hamfest. Milford ARC, Chris Reinfelder KB8SNH, 513-753-5066.
E-Mail: kb8snh@cs.com

TN - NASHVILLE - Hamfest. Nashville ARC, Bob Malone WB5ZDS, 615-865-6225.
E-Mail: bmalone5@juno.com

VA - FRANKLIN - Hamfest. Franklin AR Repeater Assn., Ralph Atkinson WB4ZNB, 757-562-5710

JUNE 18

CA - SANTA MARIA - Hamfest. Satellite ARC, Eric Lemmon WB6FLY, 805-733-4416.
E-Mail: wb6fly@arrl.net
Web: http://www.SatelliteARC.com

IN - CROWN POINT - Hamfest. Lake County Fairgrounds. VE testing. Talk-in: 147.00 repeater, 146.520 simplex. Lake County ARC, Jim Harney KF9EX, E-Mail: kf9ex@arrl.net

MA - CAMBRIDGE - Flea at MIT. Albany and Main Sts. 9am-2pm. Talk-in: 146.52 & 449.725/444.725 W1XM/R PL 114.8 (2A). Nick Altenbernd KA1MQX, 617-253-3776 (9-5). Web: http://web.mit.edu/w1mx/www/swapfest.html

MD - FREDERICK - Hamfest. County Fairgrounds, 797 E. Patrick St. 8am-3pm. VE testing. Talk-in: 147.060(+), 146.640(-), 146.520(x). Frederick ARC, Carolyn Moroney N3VOK, 301-831-5060. E-Mail: n3vok@erols.com

MI - MONROE - Hamfest. County Fairgrounds. Talk-in: 146.72. Monroe County Radio Communications Assn., Fred VanDaele KA8EBI, 734-587-2250 or 734-242-9487. E-Mail: ka8ebi@arrl.net Web: http://www.mcrca.org

OH - MACEDONIA - Hamfest. Nordonia High School. 8am-1pm. Talk-in: 146.82(-) repeater. Cuyahoga ARS, Rich James N8FIL, 1-800-404-2282. E-Mail: n8fil@aol.com
Web: http://www.cars.org

JUNE 24-25

CA - FERNDALE - Hamfest. Humboldt ARC, Marcy Campbell KE6IAU, 707-442-3866.
E-Mail: marcidon@quik.com
Web: http://www.humboldt.com

JULY 2000

JULY 2

PA - LEHMAN - Hamfest. Luzerne County Fairgrounds, Rte. 118. FCC exams. Talk-in: 146.52, 146.61. Murgas ARC, Bob Michael N3FA, 570-288-3532. Frank N3WPG, 570-824-7579.
E-Mail: n3wpg@aol.com and wb3faa@aol.com

JULY 4

PA - BRESSLER - Hamfest. Emerick Cibort Park. VE testing. Harrisburg RAC, Tom Hale WU3X, 717-232-6087. E-Mail: thale@state.pa.us
Web: http://hrac.tripod.com

JULY 7-8-9

UT - BRYCE CANYON - State Convention. UT Hamfest Committee, Kathy Rudnicki N7JSH, 801-547-9218. Web: http://www.utahhamfest.org

JULY 8

CA - FONTANA - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves

CANADA - PE - SUMMERSIDE - Hamfest. Summerside ARC, Ella McCormick VE1PEI, 902-886-2280. E-Mail: mccormick@ns.sympatico.ca

GA - GAINESVILLE - State Convention. Georgia Mountains Center. 8:30am-3pm. VE Testing. Talk-in: 146.67(-). Lanierland ARC, Ken Johnson NZ4Q, 706-335-9658. E-Mail: nz4q@aol.com Web: http://www.mindspring.com/~w4tl/hamfest.htm

IN - INDIANAPOLIS - Central Division Convention. Indianapolis Hamfest Assn., Rick Ogan N9LRR, 317-257-4050.
E-Mail: oganr@in.net
Web: http://www.indyhamfest.com

COMPUTER SHOWS

AGI Shows, 317-299-8827.
E-Mail: info@agishows.com
http://www.agishows.com

Blue Star Productions
612-788-1901.
http://www.supercomputersale.com

Computers And You, 734-283-1754.
www.a1-supercomputersales.com

Computer Central Shows
847-412-1900 & 1-888-296-6066.
E-Mail: compcent@megsinet.net
www.computercentralshows.com

Computer Country Expo
847-662-0811 Web: www.ccxpo.com

Five Star Productions
810-379-3333. E-Mail: jeff@fivestar
www.fivestarshows.com

Georgia Mountain Productions
706-838-4827.
E-Mail: gamtnpro@blrg.tds.net
georgiamountain.com

Gibraltar Trade Center, Inc.
734-287-2000. Taylor, MI.
E-Mail: taylor@gibraltartrade.com
www.gibraltartrade.com

Gibraltar Trade Center, Inc.
810-465-6440. Mt. Clemens, MI.
E-Mail: mtclemens@gibraltartrade.com
www.gibraltartrade.com

KGP Productions
1-800-631-0062, 732-297-2526.
E-Mail: kgp@mail.com

MarketPro, Inc., 201-825-2229.
http://www.marketpro.com

MarketPro, Inc., 301-984-0880.
E-Mail: md@marketpro.com
http://marketpro.com

Narisaam Computer Show
770-663-0983.
E-Mail: narisaam@aol.com
Web: http://www.shownsale.com

Northern Computer Shows
978-744-8440.
E-Mail: inquiries@ncshows.com
Web: ncshows.com

Peter Trapp Computer Shows
603-272-5008.
Web: www.petertrapp.com

Events CALENDAR

MI - PETOSKEY - Hamfest. 4-H Bldg. Emmet County Fairgrounds. 8am-12pm. VE testing. Talk-in: 146.68-. Straits Area ARC, Tom W8IZS, 231-539-8459 or Dirk KG8JK, 231-348-5043, E-Mail: kg8jk@qsl.net

MO - KANSAS CITY - Hamfest. PHD ARA, Bob Roske WA0CLR, 816-436-0069.
E-Mail: wa0clr@worldnet.att.net
Web: http://members.tripod.com/~PHDARA/

NC - SALISBURY - Hamfest. Salisbury Civic Center. VE Testing. Talk-in: 146.73 tone 94.8 and 146.52 simplex. Rowan ARS, Jim Morris KA4MPP, 704-278-4960 or Carol Maher W4CLM, 704-633-6603. E-Mail: rbrown@salisbury.net Web: http://homestead.juno.com/w4clm.ham/club2.html

WI - OAK CREEK - Hamfest. The American Legion Post 434, 9327 S. Shepard Ave. 6:30am-4pm. Talk-in: 146.52 simplex. South Milwaukee ARC, Bob Kastelic WB9TIK, 414-762-3235 days & early eves.

JULY 9

IL - PEOTONE - Hamfest. Will County Fairgrounds. Talk-in: 146.94 (-600). Kankakee Area Radio Society, Don Kerouac K9NR, 815-939-7548. E-Mail: k9nr@juno.com
Web: http://www.w9az.com

OH - BOWLING GREEN - Hamfest. Wood County ARC, John Lagger AA8XS, 419-662-9686.
E-Mail: aa8xs@arrl.net Web:
http://bravais.bgsu.edu/~boughton/hamfest.html

PA - PITTSBURGH - Hamfest. Northland Public Library, 300 Cumberland Rd. 8am-3pm. Talk-in: 147.09. North Hills ARC, Keith Ostrom KB3ANK, 412-821-4135. Bob Ferrey, Jr. N3DOK, 412-367-2393, E-Mail: n3dok@pgh.net
Web: www.nharc.pgh.pa.us

JULY 14-15-16

MT - EAST GLACIER - State Convention. Glacier/Waterton Int'l Hamfest Committee, Frank Phillips AC7AY, 406-273-2894.
E-Mail: ac7ay@bigsky.net
Web: http://www.tlatech.com/hamfest/

JULY 15

CO - LOVELAND - Hamfest. Larimer County Fairgrounds, 700 Railroad Ave. 9am-4pm. VE exams. Talk-in: 145.115 (- offset) or 146.52 simplex. NCARC, Michael Taylor N7RKC, 970-203-0609 eves. E-Mail: mtaylor@hach.com
Web: http://www.info2000.com/~ncarc

MD - BRUNSWICK - Hamfest. Mid-Atlantic DX & Repeater Assn., Roy Bates N2CSQ, 301-834-9351.
E-Mail: 74163.200@compuserve.com

MI - FAIRVIEW - Hamfest. Au Sable Valley ARC, Gerry Crawford K8GER, 517-848-5996 or 517-826-8131. E-Mail: k8ger@arrl.net

NC - CARY - Hamfest. Cary ARC, Herb Lacey W3HL, 919-467-9608. E-Mail: infomanag@aol.com
Web: http://www.ipass.net/~falynch/carc/carc.html

OH - WELLINGTON - Hamfest. Lorain County Fairgrounds. 8am-2pm. VE Exams. Talk-in: 146.10/70. Northern Ohio ARS, John Shaaf KC8AOX, 216-696-5709. E-Mail: kc8aox@qsl.net

TX - SHERMAN/DENISON - Hamfest, Wilmer O. Kinsey WB5DCU, 903-893-5872.
E-Mail: wb5dcu@gte.net

TX - TEXAS CITY - Hamfest. Tidelands ARS, Joe Wileman AA5OP, 409-945-6794.
E-Mail: aa5op@aol.com

JULY 16

MA - CAMBRIDGE - Flea at MIT. Albany and Main Sts. 9am-2pm. Talk-in: 146.52 & 449.725/444.725 W1XM/R PL 114.8 (2A). Nick Altenbernd KA1MQX, 617-253-3776 (9-5). Web: http://web.mit.edu/w1mx/www/swapfest.html

MO - WASHINGTON - Hamfest. Zero Beaters ARC, Keith Wilson K0ZH, 636-629-2264. E-Mail: jwpubl@fidnet.com Web: http://zbarc.usmo.com/

NJ - AUGUSTA - Hamfest. Sussex County Fairgrounds, Plains Rd. Talk-in: 147.90/30. Sussex County ARC, Dan Carter N2ERH, 973-948-6999.
E-Mail: n2erh@email.com
Web: http://www.scarcnj.org

NY - BATAVIA - Hamfest. Genesee RA, Randy Boyle K2RLB, 716-948-9679. E-Mail: Racboyle@iinc.com Web: http://www.majordomo@hamgatel.sunyerie.edu/~gram/

OH - VAN WERT - Hamfest. Van Wert County Fairgrounds, US Rt. 127 S. 8am-3pm. Talk-in: 146.85. Van Wert OH ARC, Robert Barnes, 419-238-1877. E-Mail: barnesrl@bright.net
Web: http://www.bright.net/~barnesrl/w8fy.html

PA - KIMBERTON - Hamfest. Fire Co. Fairgrounds. Rte. 113. Talk-in: 146.835/- and 443.80/+. MARC, Bill Owen W3KRB, 610-325-

3995. E-Mail: hamfest-info@marc-radio.org
Web: http://www.marc-radio.org/hamfest.html

JULY 21-22

FL - MILTON - Hamfest. Santa Rosa County Auditorium. Fri: 5pm-9pm, Sat: 8am-2pm. FCC Exams. Talk-in: 146.70. Milton ARC, Bill Couch W4VY, 850-623-0592.
E-Mail: billcouch@sprintmail.com
Web: http://home.att.net/~k4ozl/marc.htm

JULY 22

NH - NASHUA - Hamfest. Res Ctr Church. NE Antique RC 617-923-2665
NY - FRANKFORT - Hamfest. Utica ARC, Bob Decker AA2CU, 315-797-6614.
E-Mail: ktrnd@borg.com
OH - CINCINNATI - Hamfest. Diamond Oaks Development Campus, 6375 Harrison Ave. 7am-2pm. VE Exams. Talk-in: 146.67 and 146.925. OH-KY-IN ARS, Gene McCoy N8KOJ, 513-541-6935. E-Mail: n8koj@arrl.net
Web: http://www.qsl.net/k8sch
TN - DAYTON - Hamfest. Rhea County ARS, Bob Jordan KN4VY, 423-775-3225.
E-Mail: kn4vy@arrl.net
Web: http://webcube.volstate.net/~ko4sy/

JULY 23

IL - SUGAR GROVE - Hamfest. Waubonsee Community College, Rt. 47 Harter Rd. VEC Exams. Talk-in: 147.210 (+600) PL 103.5/107.2. Fox River Radio League, Maurice Schietecatte W9CEO, 815-786-2860. E-Mail: w9ceo@arrl.net
Web: http://www.frrl.org/hamfest.html

JULY 28-29

OK - OKLAHOMA CITY - State Convention. OK State Fair Park (Hobbies, Arts & Craft Bldg.). Fri: 5-8pm, Sat: 8am-5pm. Talk-in: 146.82. Central OK Radio Amateurs, Harold Miller KB1ZQ, 405-672-7735 or 405-650-9963. E-Mail: n1lpn@swbell.net
Web: http://www.geocities.com/heartland/7332
TX - AUSTIN - Convention. Austin ARC, Austin Repeater Group, Texas VHF-FM Society, Joe Makeever W5HS, 512-345-0800

JULY 28-29-30

AZ - FLAGSTAFF - State Convention. Ft. Tuthill. Fri: 12pm-5pm, Sat: 9am-5pm, Sun: 9am-2pm. VE Testing. Talk-in: 146.980 MHz with 100.0 Hz PL Tone. ARCA, Norm Martin K7OLD, 520-297-9562. E-Mail: norm@hamsrus.com
Web: http://www.hamsrus.com/tuthill.html
CANADA - BC - VANCOUVER - Pacific Northwest DX Convention. BC DX Club & Fraser DX Club, Dave Johnson VE7VR, 604-438-8715.
E-Mail: ve7vr@rac.ca Web: http://www.bcdxc.org

JULY 29

NC - WAYNESVILLE - Hamfest. Western Carolina ARS, Pat Kelsey AB5RB, 828-236-0181.
E-Mail: ab5rb@bellsouth.net
Web: http://www.wcars.org/hamfest2000
OR - BANDON - Hamfest. Coos County RC, Brian Howard W7MLT, 541-572-5623.
E-Mail: w7mlt@usa.net

JULY 30

MD - TIMONIUM - Hamfest. Timonium Fairgrounds. Talk-in: 147.03+ and 224.96-. BRATS, Mayer Zimmerman W3GXK, 410-461-0086.E-Mail: w3gxk@arrl.net
Web: http://www.smart.net/~brats
OH - RANDOLPH - Hamfest. Portage ARC, Joanne Solak KJ3O, 330-274-8240. E-Mail: ljsolak@apk.net Web: http://parc.portage.oh.us

AUGUST 2000

AUGUST 5

MI - TAWAS - Hamfest. Iosco County AR Enthusiasts, John Hanley KA8AIP, 517-756-2845.
E-Mail: ka8aip@centurytel.net
Web: http://www.oscoda.net/icare/
NM - ROSWELL - Hamfest. Pecos Valley ARC, Vernetta Verasso KC5WKA, 505-627-7777. E-Mail: kc5wka@dfn.com Web: http://www.pvarc.com
NY - ITHACA - Hamfest. Tompkins County Airport. 7am-2pm. VE testing. Talk-in: 146.97. Tompkins County ARC, Richard Spingarn AA2UP, 607-387-5251. E-Mail: richard@eagleprint.com
Web: http://www.compcenter.com/~tcarc
OH - COLUMBUS - Hamfest. Voice of Aladdin ARC, James Morton KB8KPJ, 614-846-7790.
E-Mail: kb8kpj@cs.com

AUGUST 5-6

WA - SPOKANE - Eastern WA Section Convention. NW Tri-State ARO, Palouse Hills ARC, Inland Empire VHF & Spokane RA, Kamiak Butte Am. Rptr., Betsy Ashleman N7WRQ, 509-448-5821. E-Mail: n7wrq@aol.com
Web: http://www.iea.com/~n7utg

AUGUST 6

IN - ANGOLA - Hamfest. Land of Lakes, Bill Brown WD9DSN, 219-475-5897.
E-Mail: sharon.l.brown@gte.net
VA - BERRYVILLE - Hamfest. Clarke County Ruritan Fairgrounds. VE Exams. Talk-in: 146.82-. Shenandoah Valley ARC, Irvin Barb W4DHU, 540-955-1745. E-Mail: ibarb@visuallink.com
Web: http://www.vvalley.com/svarc/hamfest
WI - MARSHFIELD - HAMNIC. Marshfield Area ARS, Guy Boucher KF9XX, 715-384-4323.
E-Mail: guyboucher@tznet.com

AUGUST 12

CA - FONTANA - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves
IL - QUINCY - Hamfest. Eagles Alps Grounds, 3737 N. 5th St. 8am-2pm. VEC Testing. Talk-in: 147.63/147.03. Western IL ARC, Jim Funk N9JF, 217-336-4191. E-Mail: jfunk@adams.net
Web: http://www.qsl.net/w9awe
NY - ROME - Hamfest. Rome RC, Russell Schorer KB2MAS, 315-853-8739.
E-Mail: w4bny@juno.com
VT - BURLINGTON - Hamfest. Burlington ARC, Renee Berteau N1UXK, 802-893-7660.
E-Mail: n1uxk@juno.com
Web: http://www.together.net/~kd1r/fest00.htm
WV - HUNTINGTON - Hamfest. Tri-State ARA, Dwight D. Smith, Sr. WB8JPJ, 304-522-7865.
E-Mail: wb8jpj@home.com

AUGUST 13

IA - AMANA - Hamfest. Amana Outdoor Convention Center. VE Exams. Talk-in: 146.745/.145 and 146.520. Cedar Valley ARC, Chuck Bassett N0UTS, 319-378-0448.
E-Mail: n0uts@rf.org Web: http://cvarc.rf.org
IN - GREENTOWN - Hamfest. Greentown Lions Club Fairgrounds. Kokomo & Grant County ARCs, L.B. (Nick) Nickerson KA6NQW, 765-668-4814.
E-Mail: ka6nqwnick@netusa1.net Web: http://www.netusa1.net/~ka6nqwnick/hamfest.html
MA - ORANGE - Hamfest. Mohawk ARC, John Dould AE1B, 978-249-5905. E-Mail: ae1b@gis.net
MI - JACKSON - Hamfest. Cascade ARS, Dennis Byrne KC8IJZ, 517-522-4058 or 517-796-6966.
E-Mail: byrneda@voyager.net
Web: http://www.qsl.net/cars-jxn
MN - ST. JOSEPH - Hamfest. St. Cloud ARC, Linden Scott Hall KA0DAQ, 320-252-4498.
E-Mail: lscotth@aol.com
Web: http://www.w0sv.org/hamfest.html

FET PRINCIPLES AND CIRCUITS Part 2

Field-Effect Transistors

by Ray Marston

Ray Marston looks at practical JFET circuits in this second episode of this four-part series.

Last month's opening episode explained (among other things) the basic operating principles of JFETs. JFETs are low-power devices with a very high input resistance and invariably operate in the depletion mode, i.e., they pass maximum current when the gate bias is zero, and the current is reduced ('depleted') by reverse-biasing the gate terminal.

Most JFETs are n-channel (rather than p-channel) devices. Two of the oldest and best known n-channel JFETs are the 2N3819 and the MPF102, which are usually housed in TO92 plastic packages with the connections shown in *Figure 1*; *Figure 2* lists the basic characteristics of these two devices.

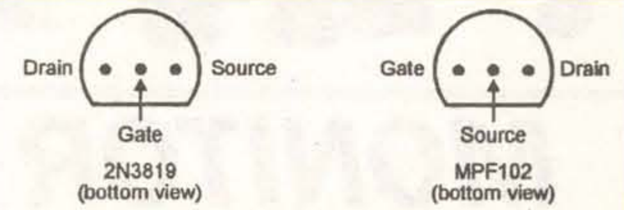
This month's article looks at basic usage information and applications of JFETs. All practical circuits shown here are specifically designed around the 2N3819, but will operate equally well when using the MPF102.

JFET BIASING

The JFET can be used as a linear amplifier by reverse-biasing its gate relative to its source terminal, thus driving it into the linear region. Three basic JFET biasing techniques are in common use. The simplest of these is the 'self-biasing' system shown in *Figure 3*, in which the gate is grounded via Rg, and any current flowing in Rs drives the source positive relative to the gate, thus generating reverse bias.

Suppose that an I_D of 1mA is wanted, and that a V_{GS} bias of -2V2 is needed to set this condition; the correct bias can obviously be obtained by giving Rs a value of 2k2; if I_D tends to fall for some reason, V_{GS} naturally falls as well, and thus makes I_D increase and counter the original change; the bias is thus self-regulating via negative feedback.

Figure 1. Outline and connections of the 2N3819 and MPF102 JFETs.



Parameter	2N3918	MPF102
V_{DS} max (= max. drain-to-source voltage)	25V	25V
V_{DG} max (= max. drain-to-gate voltage)	25V	25V
V_{GS} max (= max. gate-to-source voltage)	-25V	-25V
I_{DSS} (= drain-to-source current with V_{GS} = 0V)	2-20mA	2-20mA
I_{GSS} max (= gate leakage current at 25° C)	2nA	2nA
P_T max (= max. power dissipation, in free air)	200mW	310mW

Figure 2. **Basic characteristics of the 2N3819 and MPF102 n-channel JFETs.**

In practice, the V_{GS} value needed to set a given I_D varies widely between individual JFETS, and the only sure way of getting a precise I_D value in this system is to make Rs a variable resistor; the system is, however, accurate enough for many applications, and is the most widely used of the three biasing methods.

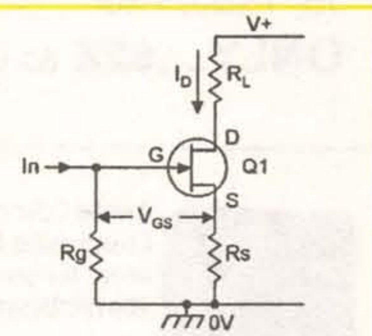
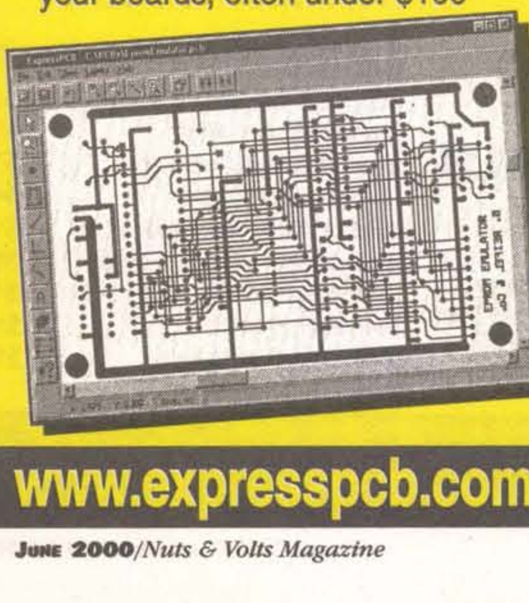
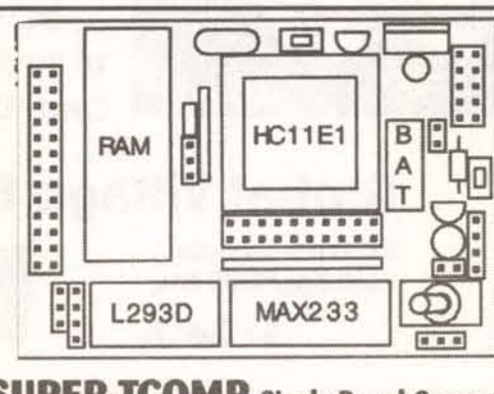


Figure 3. **Basic JFET 'self-biasing' system.**

A more accurate way of biasing the JFET is via the 'offset' system of *Figure 4(a)*, in which divider R1-R2 applies a fixed positive bias to the gate via Rg, and the source voltage equals this voltage minus V_{GS}. If the gate voltage is large relative to V_{GS}, I_D is set mainly by Rs and is not greatly influenced by V_{GS} variations. This system thus enables I_D values to be set with good accuracy and without need for individual component selection. Similar results can be obtained by grounding the gate and taking the bottom of Rs to a large negative voltage, as in *Figure 4(b)*.

The third type of biasing system is shown in *Figure 5*, in which constant-current generator Q2 sets the I_D, irrespective of the JFET characteristics. This system gives excellent biasing stability, but at the expense of increased circuit complexity





and cost.

In the three biasing systems described, Rg can have any value up to 10M, the top limit being imposed by the volt drop across Rg caused by gate leakage currents, which may upset the gate bias.

SOURCE FOLLOWER CIRCUITS

When used as linear amplifiers, JFETs are usually used in either the source follower (common drain) or common-source modes. The source follower gives a very high input impedance and near-unity voltage gain (hence the alternative title of 'voltage follower').

Figure 6 shows a simple self-biasing (via RV1) source follower; RV1 is used to set a quiescent R2 volt-drop of 5V6. The circuit's actual input-to-output voltage gain is 0.95. A degree of bootstrapping is applied to R3 and increases its effective impedance; the circuit's actual input impedance is 10M shunted by 10pF, i.e., it is 10M at very low frequencies, falling to 1M0 at about 16kHz and 100k at 160kHz, etc.

Figure 7 shows a source follower with offset gate biasing. Overall voltage gain is about 0.95. C2 is a bootstrapping capacitor and raises the input impedance to 44M, shunted by 10pF.

Figure 8 shows a hybrid (JFET plus bipolar) source follower. Offset biasing is applied via R1-R2, and constant-current generator Q2 acts as a very high-impedance source load, giving the circuit an overall voltage gain of 0.99. C2 bootstraps R3's effective impedance up to 1000M, which is shunted by the JFET's gate impedance; the input impedance of the complete circuit is 500M, shunted by 10pF.

Note then if the high effective value of input impedance of this circuit is to be maintained, the output must either be taken to external loads via an additional emitter follower stage (as shown dotted in the diagram) or must be taken only to fairly high impedance loads.

COMMON SOURCE AMPLIFIERS

Figure 9 shows a simple self-biasing common source amplifier; RV1 is used to set a quiescent 5V6 across R3. The RV1-R2 biasing network is AC-decoupled via C2, and the circuit gives a voltage gain of 21dB (= x12), and has a ±3dB frequency response that spans 15Hz to 250kHz and an input impedance of 2M2 shunted by 50pF. (This high shunt value is due to Miller feedback, which multiplies the JFET's effective gate-to-drain capacitance by the circuit's x12 Av value.)

Figure 10 shows a simple self-biasing headphone amplifier that can be used with headphone impedances of 1k0 or greater. It has a built-in volume control (RV1), has an input impedance of 2M2, and can use any supply in the 9V to 18V range.

Figure 11 shows a self-biasing add-on pre-amplifier that gives a voltage gain in excess of 20dB, has a bandwidth that extends beyond 100kHz, and has an input impedance of 2M2. It can be used with any amplifier that can provide a 9V to 18V power source.

JFET common source amplifiers can — when very high biasing accuracy is needed — be designed using either the 'offset' or 'constant-current' biasing technique. *Figures 12* and *13* show circuits of these types. Note that the 'offset' circuit of *Figure 12* can be used with supplies in the range 16V to 20V only, while the hybrid circuit of *Figure 13* can be used with any supply in the 12V to 20V range. Both circuits give a voltage gain of 21dB, a ±3dB bandwidth of 15Hz to 250kHz, and an input impedance of 2M2.

DC VOLTMETERS

Figure 14 shows a JFET used to make a very simple and basic three-range DC voltmeter with a maximum FSD sensitivity of 0.5V and an input impedance of 11M1. Here, R6-RV2 and R7 form a potential divider across the 12V supply and — if the R7-RV2 junction is used as the circuit's zero-voltage point — sets the top of R6 at +8V and the bottom of R7 at -4V. Q1 is used as a source follower, with its gate grounded via the R1 to R4 net-

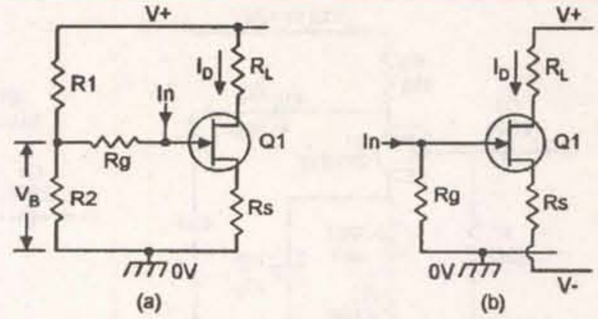


Figure 4. Basic JFET 'offset-biasing' system.

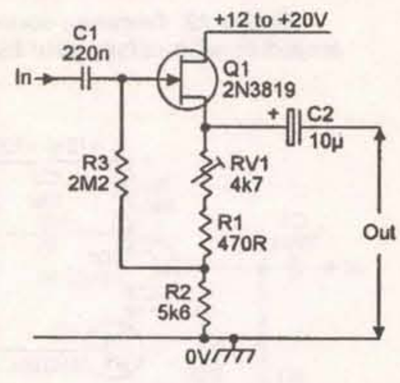


***Figure 6.* Self-biasing source-follower. Zin = 10M.**

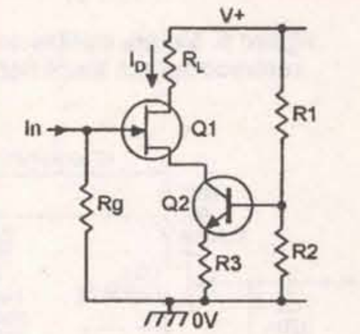


***Figure 5.* Basic JFET 'constant-current' biasing system.**

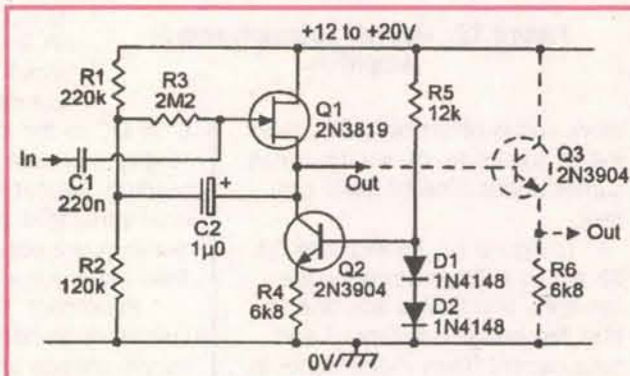


***Figure 8.* Hybrid source follower. Zin = 500M.**

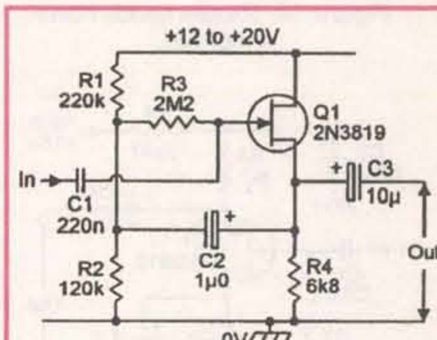


***Figure 7.* Source follower with offset biasing. Zin = 44M.**

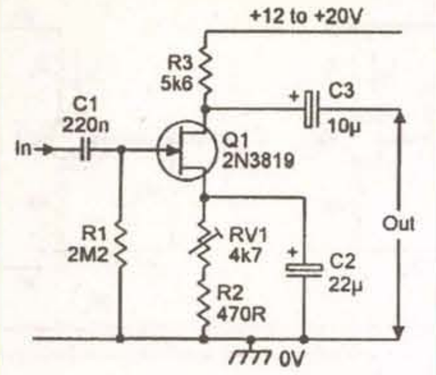


***Figure 9.* Simple self-biasing common-source amplifier.**

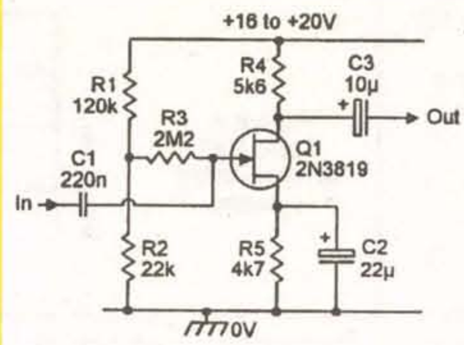


***Figure 12.* Common-source amplifier with offset gate biasing.**

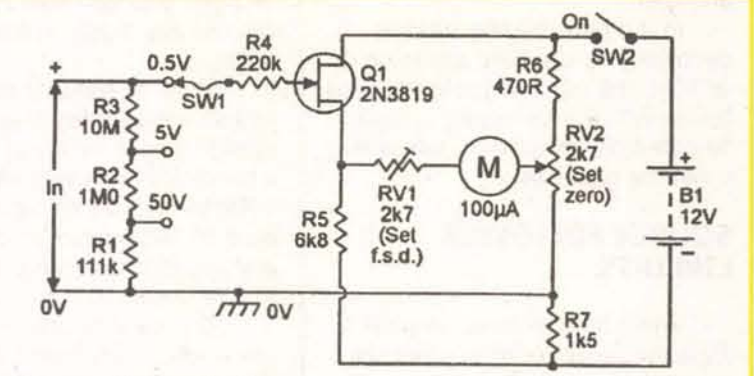


***Figure 14.* Simple three-range DC voltmeter.**

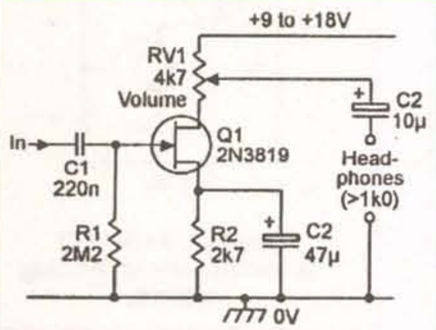


***Figure 10.* Simple headphone amplifier.**

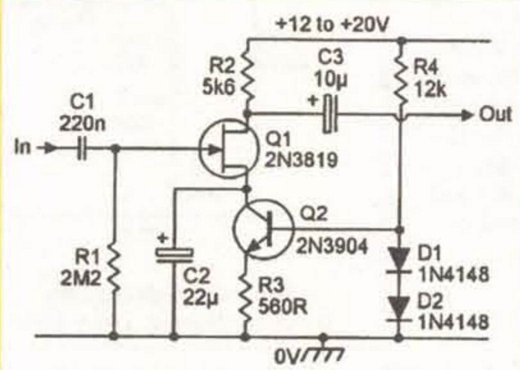


***Figure 13.* 'Hybrid' common-source amplifier.**

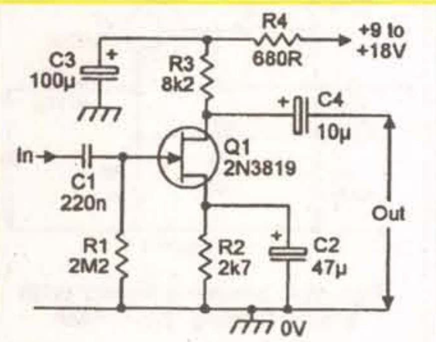


***Figure 11.* General-purpose add-on pre-amplifier.**

work and is offset biased by taking its source to -4V via R5; it consumes about 1mA of drain current.

In *Figure 14*, R6-RV2 and Q1-R5 act as a Wheatstone bridge network, and RV2 is adjusted so that the bridge is balanced and zero current flows in the meter in the absence of an input voltage at Q1 gate. Any voltage applied to Q1 gate then drives the bridge out of balance by a proportional amount, which can be read directly on the meter.

R1 to R3 form a range multiplier network that – when RV1 is correctly adjusted – gives FSD ranges of 0.5V, 5V, and 50V. R4 protects Q1's gate against damage if excessive input voltage is applied to the circuit.

To use the *Figure 14* circuit, first trim RV2 to give zero meter reading in the absence of an input voltage, and then connect an accurate 0.5V DC to the input and trim RV1 to give a precise full-scale meter reading. Repeat these adjustments until consistent zero and full-scale readings are obtained; the unit is then ready for use.

In practice, this very simple circuit tends to drift with variations in supply voltage and temperature, and fairly frequent trimming of the zero control is needed. Drift can be greatly reduced by using a zener-stabilized 12V supply.

Figure 15 shows an improved low-drift version of the JFET voltmeter. Q1 and Q2 are wired as a differential amplifier, so any drift occurring on one side of the circuit is automatically countered by a similar drift on the other side, and good stability is obtained. The circuit uses the 'bridge' principle, with Q1-R5 forming one side of the bridge and Q2-R6 forming the other. Q1 and Q2 should ideally be a matched pair of JFETs, with I_{DSS} values matched within 10%. The circuit is set up in the same way as that of *Figure 14*.

MISCELLANEOUS JFET CIRCUITS

To conclude this month's article, *Figures 16* to *19* show a miscellaneous collection of useful JFET circuits. The *Figure 16* design is that of a very-low-frequency (VLF) astable or free-running multivibrator; its on and off periods are controlled by C1-R4 and C2-R3, and R3 and R4 can have values up to 10M.

With the values shown, the circuit cycles at a rate of once per 20 seconds, i.e., at a frequency of 0.05Hz; start button S1 must be held closed for at least one second to initiate the astable action.

Figure 17 shows – in basic form – how a JFET and a 741 op-amp can be used to make a voltage-controlled amplifier/attenuator. The op-amp is used in the inverting mode, with its voltage gain set by the R2/R3 ratio, and R1 and the JFET are used as a voltage-controlled input attenuator.

When a large negative control voltage is fed to Q1 gate, the JFET acts like a near-infinite resistance and causes zero signal attenuation, so the circuit gives high overall gain but, when the gate bias is zero, the FET acts like a low resistance and causes heavy signal attenuation, so the circuit gives an overall signal loss.

Intermediate values of signal attenuation and overall gain or loss can be obtained by varying the control voltage value.

Figure 18 shows how this voltage-controlled attenuator technique can be used to make a 'constant volume' amplifier that produces an output signal level change of only 7.5dB when the input signal level is varied over a 40dB range (from

3mV to 300mV RMS).

The circuit can accept input signal levels up to a maximum of 500mV RMS Q1 and R4 are wired in series to form a voltage-controlled attenuator that controls the input signal level to common emitter amplifier Q2, which has its output buffered via emitter follower Q3.

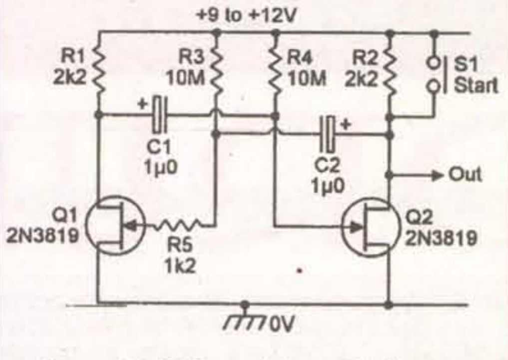
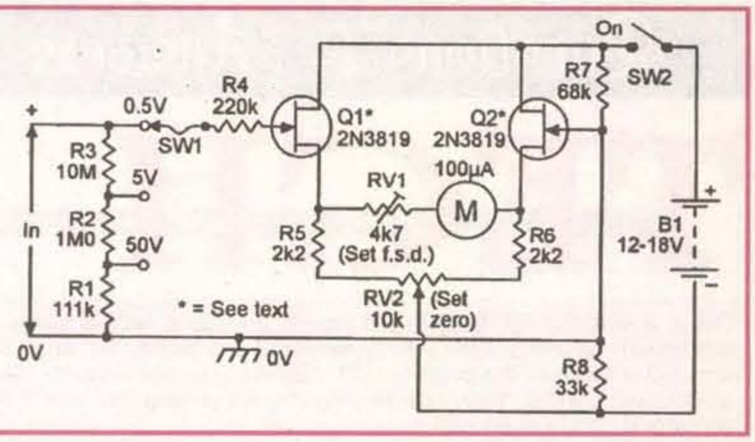


***Figure 16.* VLF astable multivibrator.**

***Figure 15.* Low-drift three-range DC voltmeter.**



Q3's output is used to generate (via C5-R9-D1-D2-C4-R5) a DC control voltage that is fed back to Q1's gate, thus forming a DC negative-feedback loop that automatically adjusts the overall voltage gain so that the output signal level tends to remain constant as the input signal level is varied, as follows.

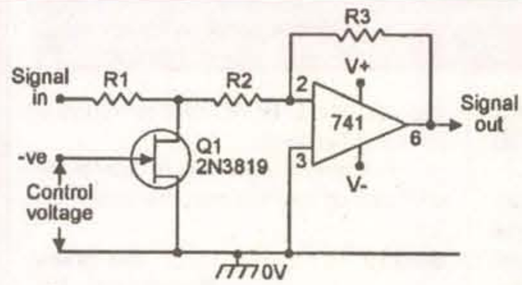


***Figure 17.* Voltage-controlled amplifier/attenuator.**

When a very small input signal is applied to the circuit, Q3's output signal is also small, so negligible DC control voltage is fed to Q1's gate; Q1 thus acts as a low resistance under this condition, so almost the full input signal is applied to Q2 base, and the circuit gives high overall gain.

When a large input signal is applied to the circuit, Q3's output signal tends to be large, so a large DC negative control voltage is fed to Q1's gate; Q1 thus acts as a high resistance under this condition, so only a small part of the input signal is fed to Q2's base, and the circuit gives low overall gain.

Thus, the output level stays fairly constant over a wide range of input signal levels; this characteristic is useful in cassette recorders, intercoms, and telephone amplifiers, etc.

Finally, *Figure 19* shows a JFET used to make a DC-to-AC converter or 'chopper' that produces a square-wave output with a peak amplitude equal to that of the DC input voltage.

In this case, Q1 acts like an electronic switch that is wired in series with R1 and is gated on and off at a 1kHz rate via the Q2-Q3 astable circuit, thus giving the DC-to-AC conversion. Note that Q1's gate-drive signal amplitude can be varied via RV1; if too large a drive is used, Q1's gate-to-source junction starts to avalanche, causing a small spike voltage to break through the drain and give an output even when no DC input is present.

To prevent this, connect a DC input and then trim RV1 until the output is just on the verge of decreasing; once set up in this way, the circuit can be reliably used to chop voltages as small as a fraction of a millivolt. **NV**

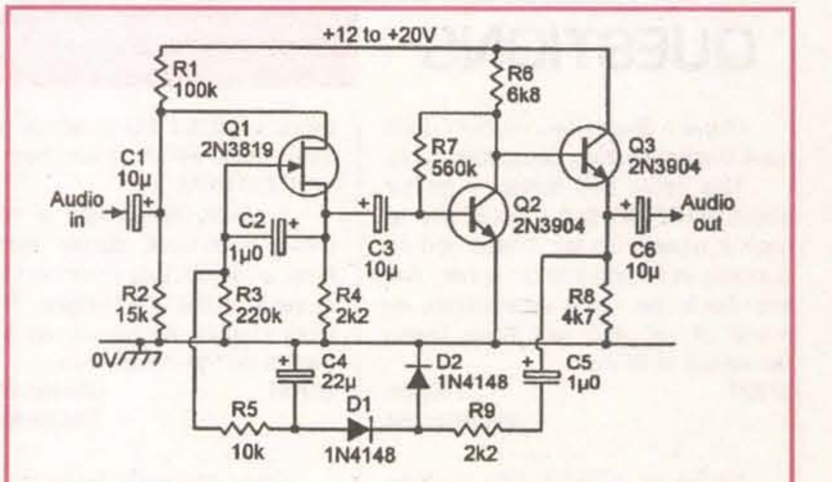


***Figure 18.* Constant-volume amplifier.**

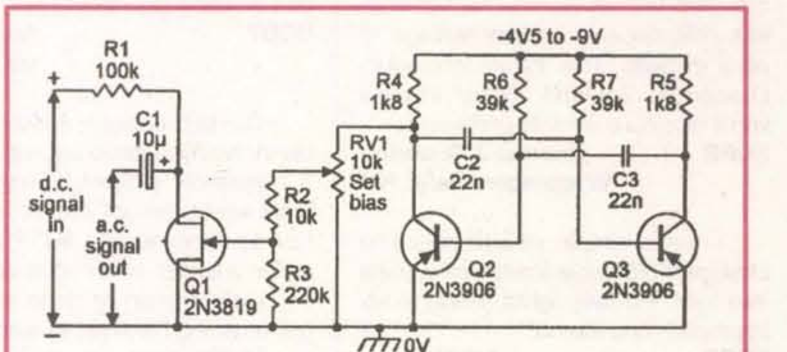


***Figure 19.* DC-to-AC converter or 'chopper' circuit.**

Next time, Ray looks at practical MOSFET and CMOS circuits.

Questions & Answers

TECH FORUM

This is a READER TO READER Column. All questions AND answers will be provided by *Nuts & Volts readers* and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. All questions submitted are subject to editing and will be published on a space available basis if deemed suitable to the publisher. All answers are submitted by readers and *NO GUARANTEES WHATSOEVER* are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

QUESTIONS

Send all material to **Nuts & Volts Magazine**, 430 Princeland Court, Corona, CA 92879, OR fax to (909) 371-3052, OR E-Mail to **forum@nutsvolts.com**

I have a Sharp Zaurus, but I don't have the connecting computer cable.

This cable and software go for about $125.00, but I would like to hack it myself. So far, I have had no success in finding info on specs. Any info would be really appreciated by many of us who still have these dinosaurs of PDAs.

6001 **Chris**
via Internet

I have an ICOM IC-RIO receiver that works okay on alkaline batteries. When replaced with NiCad batteries, the radio will not work at all. The one-volt difference in battery voltage is very critical. The radio was purchased in England. Does anyone know of a cure for this problem?

6002 **Antonio J. Anzevino**
Wappingers Falls, NY

I need a simple, reliable circuit to change motorcycle front turn signals into turn/running lights (using existing switch and lamps).

6003 **Art Heyman**
Apple Valley, CA

I am interested in scanning pixel values from my color webcam, if possible, while it is running. I am theorizing that the webcam writes values to 'video' memory which the computer then uses to generate the picture on the screen. If this is the case, then my missing link is the program to read this value while the camera is running in the 'background.'

First of all, is this possible? Is my theorizing correct? What programming language is recommended? How do I run both camera and program at the same time?

6004 **Jim**
via Internet

I'm looking for a simple interface for the video LANC serial data. I would like to use — for example — a BASIC Stamp to generate and read LANC data.

6005 **Larry Sheingorn**
Rockville, MD

I would like to add an electric motor to give my car a 15 to 20 HP boost. The car is a dirt track Super Stock with a 350 CID engine.

A typical race is 20 laps with lap times of about 20 seconds per lap. The engine RPM varies from 4500 to 6500 RPM.

I would like to use a common motor such as a starter motor and have a simple belt drive to the front or back of the 350 engine. The controls may be as simple as a micro switch on the accelerator.

6006 **Steven Schmitt**
Rochester, MN

Does someone know of a company that can reprogram doorbell sounds in wireless doorbells or who has wireless doorbells kits?

6007 **Anonymous**
via Internet

The LED chaser/sequencer article in the April issue got me going on a sequencer project. Everything I've tried works except I can't figure out how to cascade one 4017 to another for a larger continuous count.

I know it can be done, but I can't get anything I've tried to work.

Multiplexing is one way to increase the count, but I want to add a Darlington array to the output of each count to operate a relay. This works fine on a single 4017 with 10 counts. How do I get it up to 18 or 19 using two 4017s?

6008 **Walter Bringsauf**
Towaco, NJ

Does anyone have information on how to build a shift register circuit for generating pseudo random output sequences? I believe that modern techniques may call this encoding, but I'm not sure.

6009 **Henry Root**
Lunenburg, MA

I recently purchased a Sony color monitor, #CPD 9000. It has a EIAJ-8 connector marked "RGB IN" What is it, and can I use it for video?

60010 **Matthew Augugliaro**
Smiths Creek, MI

I would like to attach infrared LEDs to my CCD camera to have the ability to view in low-light situations.

I have seen CCD with the infrared LEDs in a circular pattern around the lens. I would like to build a similar type of unit.

For the power source, I want to tap into the 24V AC that is supplied with the camera.

Is there a web site or someone that can supply me with the schematics.

60011 **Bill Briley**
Buena Park, CA

ANSWERS

ANSWER TO #4003 - APRIL 2000

I need a circuit that will interface with a PC-type keyboard and display on an LCD display the characters typed.

See Feb. '99 issue of *Popular Electronics*. Front cover article by Carl J. Berquist "Liquid Crystal Displays-The Easy Way," or by the kit form of this article from **BG Micro**, P.O. Box 280298, Dallas, TX 75228; **www.bgimicro.com**

Kit #1012 PIC-an-LCD Driver board kit. Complete with LCD, PC board, programmed PIC, and crystal. I built the kit, it works fine.

David H. Bevel
Norcross, GA

ANSWER TO #50014 - MAY 2000

Is there a simple way to relocate or extend the 2.4 GHz antenna mounted on a digital, spread spectrum telephone base unit.

The best operating location of my base unit is the one that is terrible for communicating. The good choice would be to have the antenna relocated about 10 feet vertically to a floor above.

The base unit probably needs both a phone jack and an AC power outlet.

Relocating those items is a mechanical chore, but extending a 2.4 GHz antenna sounds like an RF project.

I would take the low road: Provide telephone and AC power outlets near the location that is best for the antennae.

Jack Dennon
Warrenton, OR

ANSWER TO #5007 - MAY 2000

I recently bought a pair of 900 MHz wireless headphones.

The manual says don't connect to a speaker output.

Has anyone got a simple design for an AGC amplifier with 1V P-P output, so that I may use this with a speaker output?

Your manual is correct, you should not connect your wireless headphones directly to the speakers output.

You don't want an "AGC amplifier," you need a dynamic output with a limited output. The circuit shown will limit the output to approximately

ANSWER INFO

- Include the question number that appears directly below the question you are responding to.
- Payment of $25.00 will be sent if your answer is printed. Be sure to include your mailing address if responding by E-Mail.
- In most cases, only one answer per question will be printed.
- Your name, city, state, and E-Mail address, (if submitted by E-Mail), will be printed in the magazine, unless you notify us otherwise with your submission.
- The question number and a short summary of the original question will be printed above the answer.
- Unanswered questions from a past issue may still be responded to.
- Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

QUESTION INFO

TO BE CONSIDERED FOR PUBLICATION

All questions should relate to one or more of the following:
1) Circuit Design 3) Problem Solving
2) Electronic Theory 4) Other Similar Topics

INFORMATION/RESTRICTIONS

- No questions will be accepted that offer equipment for sale or equipment wanted to buy.
- Selected questions will be printed one time on a space available basis.
- Questions may be subject to editing.

HELPFUL HINTS

- Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
- Write legibly (or type). If we can't read it, we'll throw it away.
- Include your Name, Address and Phone Number. Only your name will be published with the question, but we may need to contact you.

1.5V p-p. If you want to limit output to about 750 mV p-p, you can replace the diodes with a pair of Schottky diodes.

Set the output using R2 to a comfortable level in your headphones.

The purpose of the D1, D2 is to clamp the output the protect your headphones. Therefore, do not set R2 too high so the diodes clamp (conduct) and cause distortion. R1 will protect the diodes in case you do turn R2 all the way up.

Haim Sandel
Scottsdale, AZ

ANSWER TO #4010 - APRIL 2000

I have a Radio Plus FM sub-carrier tuner, manufactured by Fox Marketing.

There is a potentiometer, and a 10-pin dip switch to tune in channels, but I can't figure out how the dip switch settings relate to the channel frequencies.

I was the designer of the Radio Plus Subcarrier receiver that you have questions about.

I have attached a copy of the code sheet that you will need to program the radio. You can also find code sheets for the later versions of this radio on the Dayton Industrial web site, www.daytonindustrial.com

Fox Technology was the parent company of Dayton Industrial. The pot that you asked about is for squelch, this is explained in the last sheet of the attachment.

Editors Note - The code sheet referenced above is in PDF format and has been placed on the Nuts & Volts FTP site under the name scarecv.pdf

Kurt Farmer
storcom@aol.com

ANSWERS TO #5005 - MAY 2000

I need a time delay circuit for my RF power amplifier so the AC cooling fan will blow air for about three minutes after the amplifier is turned off. I would like to avoid using an expensive thermal time delay relay, if possible.

#1 It's not clear exactly what "inexpensive" means, but looking in the Allied Electronics and Newark Electronics catalogs, there are a number of solid-state time-delay relays for about $20.00+.

Amperite still makes thermal time-delay relays, as they have done for about 40 or so years that I know of, but the prices are out of sight. It used to be that the Amperite thermal time-delay relays were the cheap way to go (at just a few bucks each), but that doesn't seem to be the way it is any more.

As it happens, I have a couple of three-minute delay Amperite units left over from a project from a long time ago that didn't work out, so if Allan contacts me at hlmark@j51.com we can probably work something out.

Howard Mark
via Internet

#2 The easiest solution to delay fan turn-off is to use a 115-volt thermal reset delay relay, BR series, manufactured by Amperite Company (1-800-752-2329) at a cost of about $26.00.

However, an electronic circuit as shown in the diagram will work just as well.

A parallel RC timing circuit composed of a 4.7 megohm resistor and 22 uFd low leakage electrolytic capacitor are connected between the gate and source of a N channel enhancement mode MOSFET, BS107.

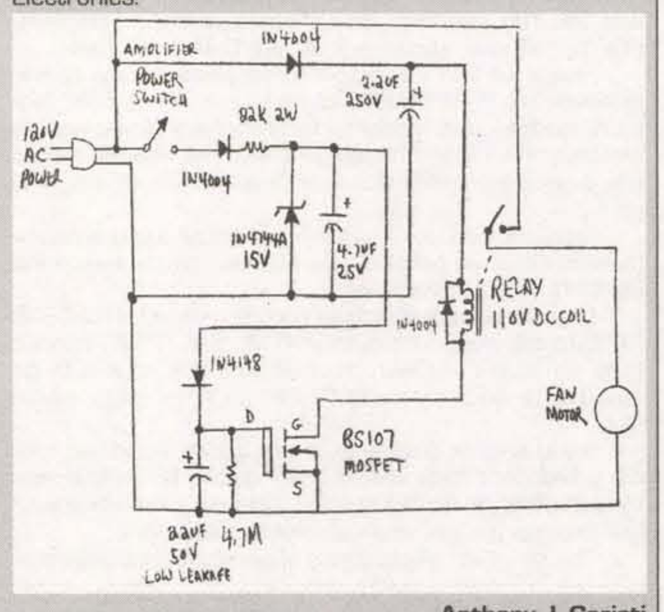
A second network composed of a 1N4004 diode and 2.2 uFd 250-volt electrolytic capacitor is connected across the AC power line and is always energized. This keeps the capacitor charged up to about 160 volts.

When the power to the fan motor is turned on, a network composed of a 1N4004 diode, 22K two-watt resistor, 15-volt zener diode, and 4.7 uFd filter capacitor is also activated at the same time, and used to charge up the RC timing circuit. This turns the MOSFET on. A relay with an 110-volt DC coil is placed between the drain of the MOSFET and the +160-volt power source. The relay is activated, and the fan motor operates.

When the power to the amplifier is turned off, there is no longer any voltage source to keep the 22 uFd capacitor charged. It discharges slowly and it takes about three or four minutes for the voltage across the timing capacitor to go below the threshold voltage of the MOSFET gate.

When this happens, the current in the relay coil goes to zero and the relay contacts open, shutting off the fan motor.

Relays with 110-volt DC coils are readily available from electronics parts suppliers such as Newark Electronics.



Anthony J. Caristi
Waldwick, NJ

ANSWERS TO #50015 - MAY 2000

There are several companies pushing 900 MHz and 2.4 GHz video/audio transmitter and receiver units commercially.

Is there a simple and legal transmitter circuit that can be purchased or constructed to use an unoccupied UHF channel that could be tuned by any TV or VCR.

#1 Unlicensed broadcast band transmitters must be 100mW, have a small antenna, and not cause interference with existing stations.

There are many other restrictions about the equipment.

Ramsey Electronics www.ramseyelectronics.com sells a TV-6 kit which will broadcast on VHF channels 3-6. In most areas, two of those channels will be unoccupied. The kit is about $30.00.

If you are adventurous, you could build your own low-band VHF (channel 2-6) TV transmitter from a Motorola MC1374..

These transmitters should require adjustment of the output filter to cut the unwanted (lower) sideband, I do not know if the Ramsey unit does this.

Failing to cut the lower sideband increases the chance of interfering with existing stations. For example, transmitting on channel 6 might interfere with the reception of channel 5.

UHF transmitters usually have a VHF modulator and a frequency translator.

It's easier to generate the vestigial sideband modulator at VHF than at UHF. These units would be more expensive, so they are therefore less common.

Ramsey also sells a C-2000 ($90.00) that transmits on cable channel 59, but it may not do audio.

Gerald Roylance
Mountain View, CA

#2 They do make a circuit that transmits directly to your TV. It's called the "Rabbit" and it tunes in somewhere around channel 60 or so. Last time I saw one they cost $49.95 and I'm sure that there are other brands out there that do the same. Check out one of the large chain stores that sell Audio/Video/TV, or consumer electronics for the latest info.

Chris
Bieber, CA

TECH FORUM

ANSWERS TO #50010 - MAY 2000

How would I get an HTML document from the Internet on a DOS-based computer?

I want my DOS-based home-automation controller to access the NWS forecast for my area, and automatically parse this report to schedule lawn watering.

I plan to get cable modem service. I'm a programmer, but have limited experience with TCP/IP other than surfing. I have seen DOS-based TCP/IP stacks for sale, but don't know how to proceed.

#1 There is free TCP/IP stack code (including source) called FNOS from Marc Blakely. Check out his site at **http://www.harbornet.com/folks/lookglas.**

The collection includes FNOS, a DOS based TCP/IP package allowing automated FTP connections to the Internet, Telnet, SMTP, POP3, and NNTP clients.

Mark Phillips
via Internet

#2 You are wise to operate a Lynx browser ported to DOS. For your weather HTML, you will like a program found in most of the Lynx packages called HTGET. Packages can be found at this site among others. **http://www.fdisk.com/doslynx/lynxport.htm**

You will also want to check out **ftp.globalnet.co.uk/simtel.net/msdos/internet.html** which is the **Simtel.Net** MS-DOS Collection.

If that site isn't good for you, a search including "Simtel" and "DOS" will give you plenty more.

While you are at it, find a version of the Pegasus E-Mail programs for DOS. You can use its mail program PMAIL or you can duplicate the header it produces and write your E-Mails in any word processor, and save as a text file. You can then mail these text files using SMTPOP12.EXE and automate it all with DOS batch files.

How it works: DOS TCP/IP configurations use a packet driver like EPPPDD.EXE which is only about 66K. Not sure about a cable modem interface, but if all you want is weather HTMLS and no big graphics, just use the dial up line. It gives you a PPP dial-up socket and you are ready to go.

Now, you can use a LYNX program as a text browser (downloading any graphics you choose), saving files, printing them, etc. It is very fast.

Or, you can use that little program called HTGET.EXE (45K) to retrieve your weather HTML files. HTGET takes a DOS command line with the URL and the file it is to be saved to. Or, you can use SMTPOP12.EXE to upload E-Mail files.

If you are not a slave to pretty pictures and can handle a keyboard fairly well, you will quickly fall in love with Lynx whether on a UNIX or DOS machine. Save using your GUI browser except when absolutely necessary.

The program offers plenty of personal customization, but there are limitations — Java, for example, and some modern SHTMLs won't transfer.

The HTGET program can be placed in a batch file with several HTMLs you want to download and it goes and gets each one, saves it to the file names you previously entered in the batch file, and quits.

You can even quit the packet driver and sign off with a batch command. With some error level batch programming, you can start it and go out to lunch. Try that with Windows.

The packet driver and GET program require just 100K of RAM.

David Osburn
via Internet

#3 If your goal is to have your home automation system do lawn watering, then add a moisture sensor instead of sucking down the NWS forecast.

These sensors are used on some irrigation controllers (I saw one at Home Depot a couple years back). Failing that, add a rain gauge to your controller (there are simple two-bucket designs for these). Then the decision to water can be based on local conditions.

I live on the San Francisco Peninsula, and the forecast rain differs a lot from the actual.

If you want to write some TCP/IP code, then do not go the DOS TCP/IP stack route. Getting a copy of Win9x (or Linux) will give you a current stack (one that knows about dynamic address protocols).

If your DOS PC is too old for the OS (486DX66), then get a new motherboard and/or CPU. In the long run, it should be less trouble than finding and learning to use an old stack. It will probably cost less, too. Also upgrade to a 32-bit compiler.

If your home automation system is a second computer, then you might have trouble connecting to the outside world. Attaching more than one computer to a cable (or a DSL) modem is a tricky problem. Most ISPs charge for extra Internet addresses, so many people use a NAT gateway.

Gerald Roylance
Mountain View, CA

#4 There are several web browsers available for DOS. If you like a graphics- based display with mouse and all, then try **Arachne: http://arachne.browser.org/**

Arachne requires a 32-bit system, (i.e., 386 or better), and a mouse.

For a text-based web browser that will run on an older box with DOS 3.3, check out Lynx. Find the whole story at: **www.oldskool.org/~tvdog**

My son will not abide Windows. DOS is his preferred system, and Lynx is his browser.

Jack Dennon
Warrenton, OR

ANSWERS TO #50019 - MAY 2000

I'm trying to find a seven-segment LED display driver chip that shows hexadecimal, that is 0-F.

#1 The Fairchild 9368 decodes four TTL inputs and drives a seven segment LED display in hexadecimal format 0 through F. Outputs are open emitters; they can source 19 milliamps into 1.7 volts.

In a 16-pin DIP package, this part is available from **Digi-Key 1-800-344-4539**. Order part #DM9368N-ND, $4.45 each.

An alternative approach is provided by the TIL311, available from **Jameco 1-800-831-4242**. This $11.95 part is more expensive, but it parks the whole marianne, the data latch, the decoder, and the LEDs all in one 14-pin DIP package, so of course it's a lot easier to use.

Jack Dennon
Warrenton, OR

#2 I believe an LED display with integrated driver will suit his request.

In the May issue on page 57, is a TIL311 Hexadecimal display with logic, from one of *Nuts & Volts* advertisers, **Alltronics, 408-943-9773; http://www.alltronics.com**

The TIL311 is Alltronics part #93S033, for $9.95 each. Just apply power and feed in the hexadecimal numeral in binary. The TIL311 is a complete LED display with latch/decoder and driver all in one! Couldn't be simpler.

E. Kirk Ellis
Pikeville, NC

ANSWERS TO #5008 - MAY 2000

A friend of mine is a shoe maker that wants to test electrical safety shoes. He needs an 18KV, 1mA AC power supply with a voltmeter and ammeter on the output.

How can I make this, or is there a product like this already available?

#1 What you need is a HIPOT tester. Hipot testers are used by electric utilities to test the insulation integrity of high-voltage devices, whether these devices are rubber goods, cable dielectric, or insulating transformer oil.

Since you are in Canada, I highly recommend getting a hold of the applicable testing standards. In the US, we follow ASTM (and sometimes IEC) standards which differ from material to material being tested. I would assume Industries Canada would have their own set of similar standards.

Since your friend wishes to test critical life-safety equipment, any equipment made or purchased must test in conformance with the applicable standard, or your friend could suffer liability for an injury resulting from an improper/inadequate test.

AC Hipot units for such testing can be obtained from HipoTronics, in Brewster, NY. They can be found at www.hipotronics.com

Phil Shewmaker
Louisville, KY

#2 The device you are looking for is called a HYPOT tester. One source is **Associated Research, Inc.** Here is their web link: **http://www.asresearch.com/**

You could build your own, but typically these test systems are calibrated to NBS traceable standards on an annual basis. The calibration service providers normally shun home brew units. Besides, the test voltages are dangerous and you may not like the liability issues that are involved.

Thomas B.
Folsom, CA

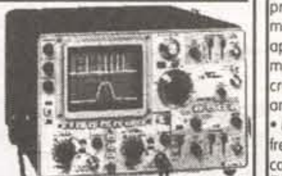
HP5335A, UNIVERSAL SYSTEMS COUNTER

Providing true automatic measurement functionality. This system has 16 built in front panel accessible measurement functions, all available via the HPIB or manually. One of the most powerful universal counters availble. Math and statistics include averaging, mean, sample size, standard deviation, engineering units display offset scale and normalization. Matched dual inputs provide 200MHz on chan. A and 100MHz on chan. B. Nine digit resolution from 30Hz to 200Mhz. 1meg. and 50 Ohm inputs. Auto trigger and much more. All the toys in one package! Excellent condition. **New......$3900 Now.....$395**

KIK PLZ-150W, ELECTRONIC LOAD

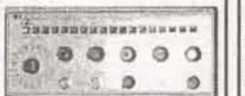
Industry workhorse, can handle loads up to 150Watts. The front panel controls allow selection of all voltage and current parameters. Current up to 30A and Voltage up to 60V can be accomodated. LED readout. Good condition. **KIK-EL..........$399ea.**

TEKTRONIX 485, 350MHz,



Probably the fastest and lowest cost scope available today. Superior performance at low cost! Dual Trace, Delayed sweep 1 nS/div Sweep rate, 5mV Vert. sensitivity. Switchable input imped., 50 ohm /1meg. Package includes 2 probes, and operation manual. Six month warranty. Excellent shape. **New....$9100 Now.......$749ea.**

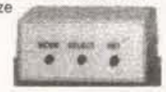
HP3312A, SWEEP FUNCTION GENERATOR



The HP3312A combines two separate, independent function generators in one instrument. The main generator can be triggered by the modulation generator to provide sweep, trigger functions, AM, FM, gate or tone burst. Up to 10V p-p into 50 Ohms. 10,000:1 output attenuator and up to 10V of DC offset are available. Freq: 0.1Hz to 13MHz. Rt <20ns, Low distortion. Excellent condition. **New....$1450 Now......$299ea.**

NEW, BY POPULAR DEMAND, Universal Time and Date generator.

Provides camera ID too! Type TG-060, is only about the size of a pack of cigarettes but solves the problem of time stamping and identifying any video signal. Has RCA jacks for video in and out. Operates from 12VDC, AC adapter included. Super simple 3 button operation. Rugged plastic case with Velcro strip for easy placement. Brand New. **SPECIAL...$49ea. 2 for $89**



FABULOUS XYZ System, Asymtek 403G series.

The Automove® 403G is a highly configurable, automatic fluid dispensing system capable of handling a full range of dispensing applications. Wherever hand-held dispensers are currently used, automating with the 403G system will increase both accuracy and throughput. Of course the system can be configured for many other motion automation applications as well. Your imagination is the key. The system can be programmed to dispense dots or continuous lines precisely and consistently using a wide variety of fluids. This flexibility makes it ideal for applications ranging from surface mount electronics to form-in-place gasketing. The system offers several standard features: At speeds of up to 508 mm/sec (20 in./s), it provides 0.025 mm (0.001 in.) resolution with a teach accuracy of 0.025 mm (0.001 in.). It is a gantry configuration with a 457 x 457 mm (18 x 18 in.) work area. Overall size: 36"W x 28"D x 20"H. Once programmed with a personal computer, the 403G stores up to 10 separate programs in onboard memory. Features. • Programmable speeds up to 508 mm/s (20 in./s) perfect for fast, short, repetitive moves required in automated applications. • Semiautomatic part skew alignment corrects for workpiece misalignment. • Easy-to use, flexible, Fluidmove® software for quick program creation is availble from the manufacturer. (Not supplied). • Eight extra inputs and outputs provide interface to I/O-triggered devices for further automation. • Multiple programs can be stored in onboard memory allowing computer-free operation in a production environment. Unit is used and in excellent condition. Ships via truck. See www.asymtek.com for info.
Reg. Price >$10K, Special Asymtek 403G..............$1895

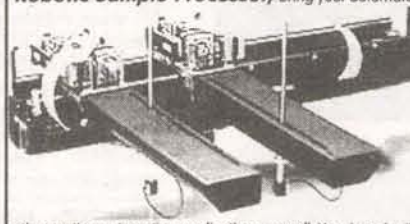
MOTOR is HEAVY DUTY and VERY PRECISE. Litton, Clifton precision type, JDH-2250-EZ-1C,

This beauty is a hefty 3 1/2 pound jewel. Size is: 5.7"L x 2.5" x 2.5" not includig the DUAL 1/4" diam shafts, each one 1.1" Long. Motor is rated for 24VDC operation, The tested RPMs are as shown:

Vin	InL	RPM
6V	128mA	373RPM
12V	158mA	768RPM
18V	160mA	1160RPM
24V	170mA	1563RPM

New, super quality. **SPECIAL....$39ea. or 2 for $69**

Robotic Sample Processor,

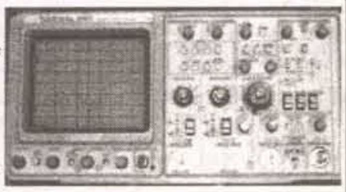


Bring your automated system up to speed with this Robotic Sample Processor. It is an XYZ module that is fast and flexible with user friendly software available. (NOT SUPPLIED) Install the RSP XYZ as the nucleus for your new system. Of course the system can be configured for many other motion automation applications as well. Your imagination is the key. Overall size: 31"W x 22"D x 7"H, X travel (dual long axis) is 22", the Y travel (dual short axis) is 12", the Z axis is limited only by the length of the rod inserted into the linear bearing unit. (user supplied). The module is supplied with dual arms as pictured, variable sensitivity liquid level sensing and encoders. The electronics support a number of auxiliary devices including diluters, valves, peristaltic pumps, sample racks and single, multichannel or cap piercing probes. Mix and match from different Cavro modules and build the system that fits your needs. The RSP can be controlled using a simple user interface (We do not have the info). Software controls the arm movements and its accessories as well as performing diagnostics and data handing functions. For more information please see www.cavro.com
Robotic Sample Processor, RSP-XYZ..........$695ea.

The SIRECUST patient monitor from Siemens,

a compact, portable patient monitoring system offers data acquisition, signal processing, display & trending. Features include: • Multichannel, multiparameter monitoring capabilities • Small, lightweight (2.6 kg - 5.7 LB), durable & water resistant • AC or battery powered • NIBP: Fast recycling "continuous" mode and artifact rejection • Automatic alarm limits & preset mode Blood Pressure labeling / auto zero Parameter Features: Monitor can measure the patient's EKG, non-invasive blood pressure & temp. & two invasive pressures. Up to five parameters can be displayed. The monitor accepts Siemens three or five-lead EKG patient cables. (no Input cables supplied) Display is 6.5" diag., easy-to-read numeric values & up to three waveforms. Alphanumerics, grids & graphics are presented on a mono, high-contrast, LCD. The EKG waveform auto centers & can be easily interpreted with the on screen mV scale. Lead I, II, or III is selectable, for best signal processing & waveform display. Systolic, diastolic & mean values are displayed. User assignable labels for all invasive pressures. Menu driven keys activate on screen labels which change according to the function selected. Used, each checked for self test and display. Offered as an experimenters item only. Not intended for medical or life support. No manuals. **Patient monitor, Sirecust............$99ea.**

TEKTRONIX 2465, 4 Chan., 300MHz, O'Scope, With on screen waveform stats



One of the most popular & powerful scopes available at a reasonable cost. Features: 500ps/Div sweep, 2mV/Div. vertical sensitivity, 1Mohm / 50-ohm input, 500Mhz trigger bandwidth, four channels. On-screen waveform cursors provide vert. & horiz. scale factors, trigger level, voltage, time, freq., phase, ratio values and mode indication. Complete with 2 probes, and manual. Excellent condition. 90 day warranty. **Very Ltd. Qty.....$2195.**

TEKTRONIX 2445, 4 Chan., 150MHz, O'Scope, With on screen waveform stats

One of the most popular & powerful scopes available at a reasonable cost. Features: 500ps/Div sweep, 2mV/Div. vertical sensitivity, 1Mohm / 50-ohm input, 500Mhz trigger bandwidth, four channels. On-screen waveform cursors provide vert. & horiz. scale factors, trigger level, voltage, time, freq., phase, ratio values and mode indication. Complete with 2 probes, and manual. Excellent condition. 90 day warranty. **Very Ltd. Qty.......$1295.**

NEW, "COLOR STEALTH CAM", MICRO SIZE, with AUDIO!

That's right! COLOR! In the same size package too! Sleek aluminum housing fits like a glove! Removeable mtg. bracket & a 1.3M cable with BNC vid., RCA aud., (internal mic) & DC pwr. jack for, no sweat hook up. Why fool around with an open P.C. board? Now you can have the "COLOR STEALTH CAM"

- 1/3" • 350 Lines
- Auto Shutter
- 270k pixels
- Focus:10mm to inf.
- 1<ounce!
- 0.7 Lux • AGC
- Pwr. 6-12V @30mA
- Std. 7 mm, 56° FOV lens
- NTSC video
- Size: 31mm sq. x 28mm d.

GM-4000S-STD w/audio SPECIAL $89ea.

B & W "STEALTH CAM", MICRO SIZE, with AUDIO!

The sleek aluminum housing fits like a glove! Removeable mtg. bracket & a 1.3M cable with BNC vid., RCA aud., (internal mic) & DC pwr. jack for, no sweat hook up. Why fool around with an open P.C. board? Now you can have the "STEALTH CAM"•1/3" CCD •410 Lines•0.3 Lux• AGC•Auto Shutter• Pwr. 12V @110mA•250k pixels•Std. 4mm, 78° FOV lens•Pinhole, 90° FOV• Focus:10mm to inf.•NTSC video•<ounce!•IR SENSITIVE•Size Std: 30mm sq. x 29mm d. PH: 16mm d, Don't confuse with LOW RES., HIGH LUX C-MOS CAMERAS. ***GM-2000S-STANDARD OR PINHOLE,*** **SPECIAL...$69ea.**

NOW YOU CAN SEE WHAT THE "FISHES ARE DOIN' (down 60 ft.) UNDERWATER B&W CAMERA with INTERNAL, INFRA-RED ILLUMINATOR!

Sleek black anodized, BRASS, housing. O-Ring sealed & WATERPROOF. Adjustabe mount incl. Specs: 1/3" CCD, 400 Lines res., 0.05 Lux sensitivity, AGC, Auto Shutter. 12VDC @225mA, 4mm, 78° FOV lens, A real glass lens. NTSC video out. Superior construction. SENSITIVE to IR. Ultra small Size only: 1.25"diam. X 2" long. With 60 ft. cable. Perfect as a remote areoa inspection camera. Great for general outdoor use as well. **GM-300KIR.......$179**

NEW! NOW YOU HAVE COLOR (down to 60 ft.) UNDERWATER.

Built-in WHITE LIGHT LED'S, Sleek black anodized, BRASS, housing. O-Ring sealed & WATERPROOF. Adjustabe mount incl. Specs: 1/4" CCD, 350 Lines res., 0.5 Lux sensitivity, AGC, Auto Shutter. 12VDC @120mA,4mm, 78° FOV lens, A real glass lens. NTSC video out. Superior construction. Ultra small Size only: 1.25"diam. X 2" long. With 60 ft. cable. Perfect as a remote area inspection camera. Now with six super bright, white LED'S! BRAND NEW,
GM-400KW-LED.............$219ea.

VICOR, TRIPLE OUTPUT POWER SUPPLY, 24VDC @ 200Watts x THREE!

Type VI-RF333-CUUU, is only 9.2"L x 7.3"W x 1.4" H but packs a punch. State of the art "Flat-Pac" switcher can operate from 100 to 240VAC input. Triple output on screw terminals with sense lines for each output. Removed from equipment, tested. **SPECIAL....$59ea. or 2 for $99**

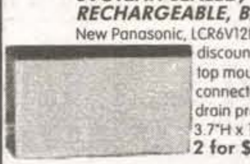
SHARP, NIMH BATTERY, Type BT-H42U, an amazing 3.6v @8.1Amp Hours in a 2.2" Cube!

This is a Brand New, Factory sealed, original equipment battery. This is THE SHARP battery not an off brand lower capacity replacement. These are very hard to find and sell for over $100. They provide over twice the power of replacement units. This is a Nickel-Metal, Hydride chemistry for NO MEMORY EFFECT. Design this puppy into your next robot. That's no typo 8100mAH or 8.1 AH! Unbelievable..... but true....true.... **SPECIAL....$49ea. or 2 for $89**

10V @ 2.5 AH SEALED, LEAD ACID, PACK.

Each pack has 5, 2 Volt cells. 'D'size cells are arrainged as 1X5 cells. Enclosed in an ABS outer shell. (removed for photo) Perfect for high drain applications. Make custom packs of any rating. Size: 7.5"L x 2.8"H x 1.5"D
SALE! 6-five packs for $20, 40 for $99

6V@12AH SEALED, RECHARGEABLE, BATTERY

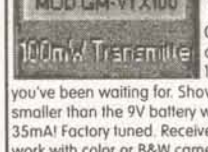


New Panasonic, LCR6V12PI. Tough to get at a discount. Very compact. Two top mounted 1/4" faston connectors. Perfect for high drain projects. Size: 5.9"L x 3.7"H x 1.9"D
2 for $20, or 10 for $89

SUPER, MINI C-MOUNT CAMERA, GM412,

The GM-412 specs: B&W, size 1.5"sq. X 2.4"L, 250,000 Pixels, 380 Lines Resolution, Sensitivity 0.3 Lux, 1/3" CCD with AGC & Electronic shutter. 12V @110mA power. NTSC out. IR SENSITIVE, BNC video out, std. DC pwr. jack. Aluminum housing with dual threaded top and bottom mounting. True performance not hype! Sturdy ball mount included. Ac power adapter included. This camera will outperform *ANY* camera in this magazine. Multi- lens options are available to exploit the superior performance. **Special, GM412...$99ea.**

WORLDS SMALLEST ••• 100mW ••• VIDEO TRANSMITTER, ON SALE



Incredibly only 0.9" x 0.8" x 0.37" Transmits crystal controlled hi-res. images with 100mW output! The transmitter you've been waiting for. Shown actual size. Much smaller than the 9V battery which powers it. Draws only 35mA! Factory tuned. Receive on cable channel 59. Will work with color or B&W cameras. UHF Bow tie antenna with balun and 3' F cable for TV Included. Perfect with our GM1000A **SPECIAL TVX-100.....$159. TVX100 with GM1000A CAMERA....$209.**

Cavro Scientific, XM Series Multi-Channel Pump,

The industry standard, Cavro's XM Series Multi-Channel pump. Now available with three channels. These brand new units were intended to use the slide to activate the plunger of a metering syringe (not supplied) to meter out and pump precision uL volumes of fluid. Each channel has an independently operated valve & can accommodate syringes ranging from 500 uL to 2.5 mL. The can automate multichannel pipetting, diluting & dispensing with independently operated solenoid valves. The pump can aspirate & dispense the same or different fluids. Inaccuracy is less than or equal to 1% at full stroke and imprecision is less than or equal to 0.05% at full stroke. Motion is supplied via a Pacific Scientific, P21NRXS-LNS-NS-03, 5.4V @1.63A unipolar stepper. This is coupled via a toothed belt to the 5.5"L lead screw with slotted optical position sensor. A slide with bronze bearings rides on a polished steel rod & provides 3" of very smooth travel. Construction is of cast and machined aluminum. Can be disassembled and modified to suit. (Software and interface info not supplied). **Multi-Channel Pump, Cavro-3XM......$89ea.**

NEW! LCD COLOR, TFT, ACTIVE MATRIX DISPLAY Offers a super 5.6" VIEWABLE AREA, Pro System with Custom Case, BUILT-IN 12V GEL CELL, all A/V cables and charger. Super Deal.

Pro System with Custom Case, BUILT-IN 12V GEL CELL, all A/V cables and charger. Super Deal. You asked for it. Finally we found a unit with exceptional quality at an affordable price. Perfect as a portable, general purpose color monitor for standard NTSC color or B&W video systems. Fully compatible with all our cameras as well as Camcorder, VCR's etc. Perfect as a rear view system with any video camera by virtue of its built in, mirror image function. Completely enclosed unit has adjustments for color, contrast and brightness and volume, for it's internal stereo speakers! A std. 1/4 x 20 Tripod socket and a tilt down stand for table top viewing. Inputs include: audio (L&R) and video on std. 1/8" mini jacks. External 12VDC on std. barrel connector. Specifications: 5.6", TFT active matrix LCD with 76.8K Pixels, CCFL backlight with 270cd/m Luminance, 500mW audio output available on std. 1/8" jack. 12V@600mA powered, 50mV min. or std. line level audio input. Overall size: 6.4"W x 5.25"H x 2.2D" New first quality. An optional accessory kit is available which includes: A luggage quality, custom made, padded case with dual removable straps for shoulder and/or holding at waist level for portable, hands free viewing. Built into the case is a 12V Gel Cell, rechargeable battery. Also supplied is a complete set of A/V cables. AC power adapter, power switch and battery charger. **GMTFT56-PRO...$344ea. GMTFT56 Display only..$299ea**

NEW, GM960 TIME LAPSE VIDEO RECORDER

Finally a brand new, 4 head, T/L recorder with all the features at a price you can afford. Features: • Up to 960 hours on a standard T-120 VHS tape.• 12 different modes for record and playback • Audio recording in the 12H and 24H mode. • 30Day memory backup • Easy mode setting.• On- screen menus • Auto-Repeat recording mode • Serial or One-shot recording • Time, Date, speed, and Alarm indicators on screen. These deluxe units are front loading and are 14"W x 3.5"H x 12.2"D, 110VAC powered.
SPECIAL, GM960-VCR ......$599ea.

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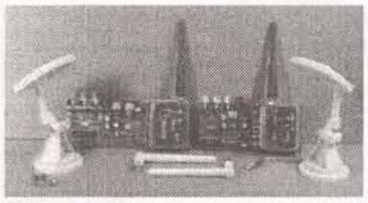
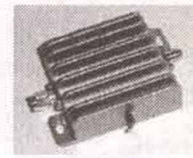
HAM GEAR FOR SALE



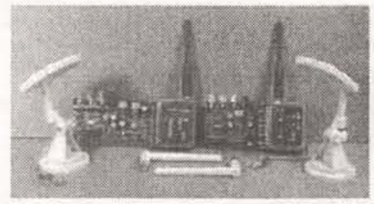
2.4GHz ATV — 8 channel TRANSMITTERS AND RECEIVERS. 35mW output power, 1 video channel, 2 audio. SMA connectors. NTSC/PAL compatible. Includes 1/4 wave rubber duck antenna. Standard frequencies are: 2398, 2405, 2412, 2416, 2420, 2428, 2435, 2442 MHz. Custom frequencies are available. See ad in this section for power amplifier. **$79/each for transmitter. $79/each for receiver.** Seabrook, 972-480-0060 (Texas, CST) or E-Mail: main@480i.com Web: www.480i.com

WANTED: MILITARY capacitors, resistors, transistors, diodes, ICs, semi's, etc. Please fax/E-Mail excess lists & RFQs 818-769-1002 fax 818-769-1084. electmatind@earthlink.net & http://www.militarycomponents.com

FOR SALE: ORBIT 360 antenna rotator. Full instructions. Never used, $40 obo. 949-494-0072.



2.4GHz POWER amplifier with power supply. 10-40 mW input, 1 (one) watt output with in-line SMA connectors and built-in heat sink. Approx. 2" x 2" x 5/8" size. Frequency range 2.3GHz-2.5GHz. **$189/each.** Compatible with all ATV product lines. See our website for more info on accessories and transmitter and receiver modules. Seabrook, 972-480-0060 (Texas, 9-6PM CST). E-Mail: main@480i.com Web: www.480i.com



1.2GHz ATV — 8 channel TRANSMITTERS and RECEIVERS. 75mW output power, 1 video channel, 2 audio. SMA connectors. NTSC/PAL compatible. Includes 1/4 wave rubber duck antenna. Standard frequencies are: 1250, 1255, 1260, 1265, 1270, 1275, 1280, 1290 MHz. Custom frequencies are available. **$79/each for transmitter. $79/each for receiver.** Seabrook, 972-480-0060 (Texas, 9-6PM CST). E-Mail: main@480i.com Web: www.480i.com

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14 Channel FRS Radio

(Family Radio Service) With CTCSS Subchannels

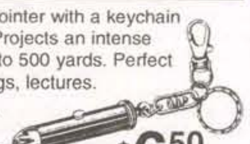
Fanon / Courier # KF-310. A light-weight, palm-sized FM transceiver. Use it at shopping malls, amusement parks or sports events. Up to a two mile range. Talk with another person who has an FRS radio set to the same frequency as your transceiver. Operates on 14 channels, with 38 CTCSS sub-channels for each channel. Speaker/ microphone jack. Backlit LCD display. Aux. Power jack. Also features VOX voice activation, auto squelch and a power-saver feature which switches on after 8 seconds of inactivity. Operates on 4 AAA alkaline or rechargeable batteries (not included). 1 Year mfg. warranty. FCC approved.

CAT# KF-310

$39.95 each unit (not per pair)

Keychain Laser Pointer

2.5" long laser pointer with a keychain and snap-clip. Projects an intense solid red dot up to 500 yards. Perfect for sales meetings, lectures. A great gift item. Includes three LR44 batteries.



CAT # LP-506 — **$6.50** each — 10 for $45.00

Digital On-Timer

Digital timer from Mr. Coffee™. Small modular design, no brand name or logo. Ideal for use in any product that needs to be turned on automatically at a specific time. Operates on 120 Vac. Switch loads ups to 10 amps. Can be switched manually. White plastic face. 2.48" X 1.77", with four digit LED clock. Overall size: 2.48" X 2.17" X 1.88" deep behind face. 0.25" qc terminals. Easy to connect and operate. Includes instruction sheet.

CAT# MCT-3 — **$5.00** each

"Ear Bud" Stereo Earphones

Miniature "in-ear" earphones for use with most portable CD, radio and tape players. 3.5 mm stereo phone plug. 32 ohm impedance. *Large Quantity Available*

CAT # HP-6

85¢ each — 10 for $7.50 — 100 for $50.00

Laser Level

Accurate and easy to use for short and long distance leveling. Center the bubble, and anything that intersects the beam is at exactly the same height. Use it to match heights in large rooms or across buildings. Set and align electrical and plumbing fixtures, cabinets and shelves. Rugged, black anodized aluminum housing with pocket clip. Locking push button switch to prevent unintended actuation. Includes two AAA batteries.

CAT # LL-1 — **$16.95** each

22 UF 450 Vdc

0.63" diameter X 1.6" long axial electrolytic capacitor.

CAT# 22/450VA — **$1.25** each — 10 for $10.00 — 100 for $80.00

16 Character X 2 Line LCD with Backlight

Daewoo # 16216L-5-VSO 5 x 7 dot format. 2.56" x 0.54" viewing area. 3.15" x 1.41" module size. LED backlight. Includes hook-up/spec sheet.

CAT# LCD-53 — **$7.50** each

3 Outlet Lighter Cord w/ Battery Monitor

Three foot cord with LED lighted, fused, 10 Amp plug at one end and three outlet jacks at other end. Jack assembly has red, yellow and green LEDs to indicate battery condition. Can be mounted via mounting ears (4.7" centers) or double-sided tape (included). Mounting ears fold out of way if not in use.

CAT # CLP-44 — **$3.75** each

Ionizer

Seawise Industrial Ltd. Model # SW750. Input: 120 Vac Output: 7.5 KV 60 Hz. The main component in a household ionization unit. 2.2" x 1" x 0.86" thick with a mounting tab that extends 0.75" from the unit. UL recognized.

CAT # SW-750 — **$4.50** each

Blue & White Ultrabrights

BLUE / water clear 1200 mcd 45 degree viewing angle.

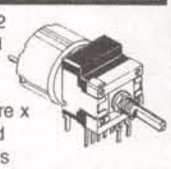
$3.75 each — CAT # LED-58 — 10 for $30.00

WHITE / water clear 1100 mcd

$4.00 each — CAT # LED-48 — 10 for $35.00

Motorized Potentiometer Dual 10K Linear Taper

Alps Electric # 726T-10KBX2 Dual 10K linear pot powered by a small reversible 6 Vdc gearhead motor. Pot and motor assembly are 1" square x 1.7" long excluding shaft and bushing. 6 mm flatted shaft is 0.5" long. 9mm threaded bushing. PC pins and mounting tabs for pc board mounting.



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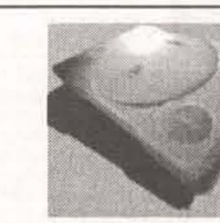

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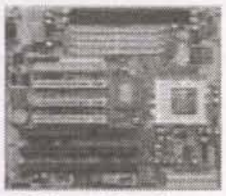

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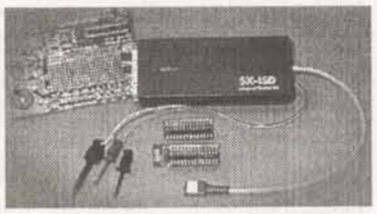

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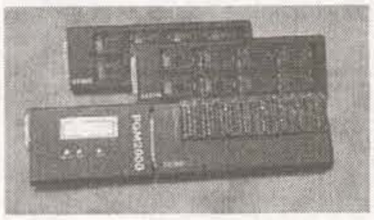

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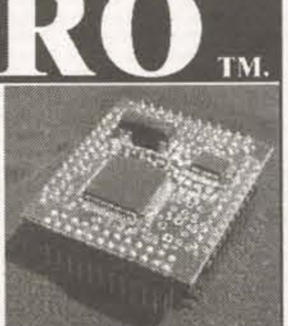

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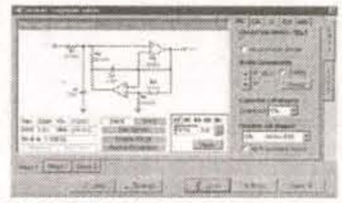

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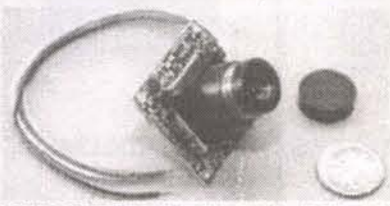

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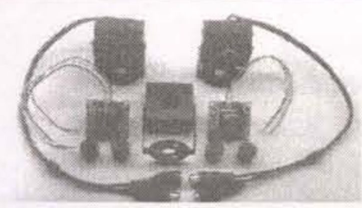

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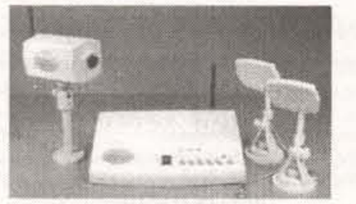

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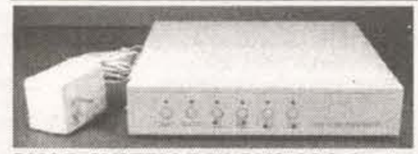

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Canon BJC-70, BJC-80	$9.95 (3-pak)	$14.95 (3-pak)
Epson Stylus Color, Color Pro, Pro XL	**$10.50**	**$14.95**
Epson Stylus Color II, IIs, 200	**$10.95**	**$14.95**
Epson Stylus Color 400, 500, 600, 800, 850,1520, Photo	**$10.95**	**$14.95**
Epson Stylus Color 440, 640, 660, 740, 760, 860	**$10.95**	**$14.95**
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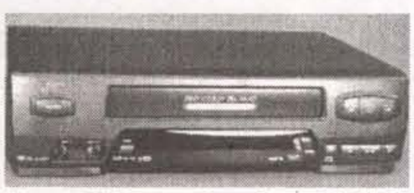

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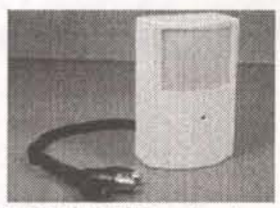

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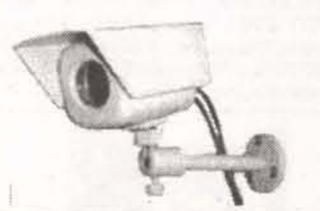

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Continued from page 55

ANOTHER AC-DC VOLTAGE REFERENCE

by Ron Tipton

You might say I'm in love with AC-DC voltage references. This article describes my latest effort, the model 306. I try to get increasingly better performance while keeping the cost to build as low as possible.

In previous models, I used a voltage divider with mechanical switches to set the output voltage. This works fine, but new Kelvin-Varley dividers are expensive and used ones are sometimes difficult to get. So my new design produces the output reference voltage directly, so a switched divider isn't needed at all. I do this by using a microprocessor to control a pair of digital-to-analog converters (DACs); one for the DC output voltage, the other for AC. Referring to the front panel photo, the left side and middle push-button switches decrement and increment the digital count to the DACs and thus vary the output voltage. The right side push button changes menus on the lower line of the LCD display for selecting voltage range, mode (AC or DC), and DC polarity. (The output voltage, range, and mode are shown on the upper display line.)

Output voltage accuracy and stability are achieved by choosing very good DC and AC references for the DACs. My measurements show that Thaler Corporation (Tucson, AZ) still makes the best DC reference ICs, so once again I used their VRE305A in the model 306. And I'm not alone in my opinion. An article in the Texas Instrument's Analog Applications Journal (Nov. '99) compares DC reference ICs from three manufacturers and gives the highest marks to Thaler. My AC voltage reference IC is also from Thaler, their SWR300.

HOW DOES IT WORK?

Besides showing the relay control and output circuit, Figure 2 is a pretty good block diagram, so let's start there in looking at how the model 306 works.

The analog output from either the AC or DC DAC is selected by relay RY1 which is controlled by the microprocessor, IC4. HIGH or LOW output voltage range is set by changing the gain of op-amp IC10. Relay RY2 changes the value of the feedback resistor for a gain of either two or four. This relay is also controlled by the microprocessor. Since IC10 is inverting, another inverter (IC11) restores the DC output to the correct polarity. IC12 is a unity gain lowpass filter and output amplifier. Its 10 kHz cutoff frequency passes the 1,000 Hz sinewave AC output with virtually no loss. But it makes the output "quieter" by reducing the broad band random noise from the preceding op-amps. The filter also practically eliminates clock noise from the microprocessor and the RS-232 converter, IC3. Ferrite beads (L1 and L2) also aid in reducing clock noise.

Now we can look at the details of generating the DC and AC voltages.

DC SIGNAL PATH

In Figure 1, a +5 volt DC reference is produced by IC9, a Thaler Corporation VRE305A. The +5 volt reference is reduced to +2.048 volts by voltage divider R28, R29, and R30, and voltage follower IC8. This voltage goes to the reference input of the DC DAC, IC6.

The program running in the microprocessor has a 16-bit counter that is incremented or decremented by front panel push-button switches S1

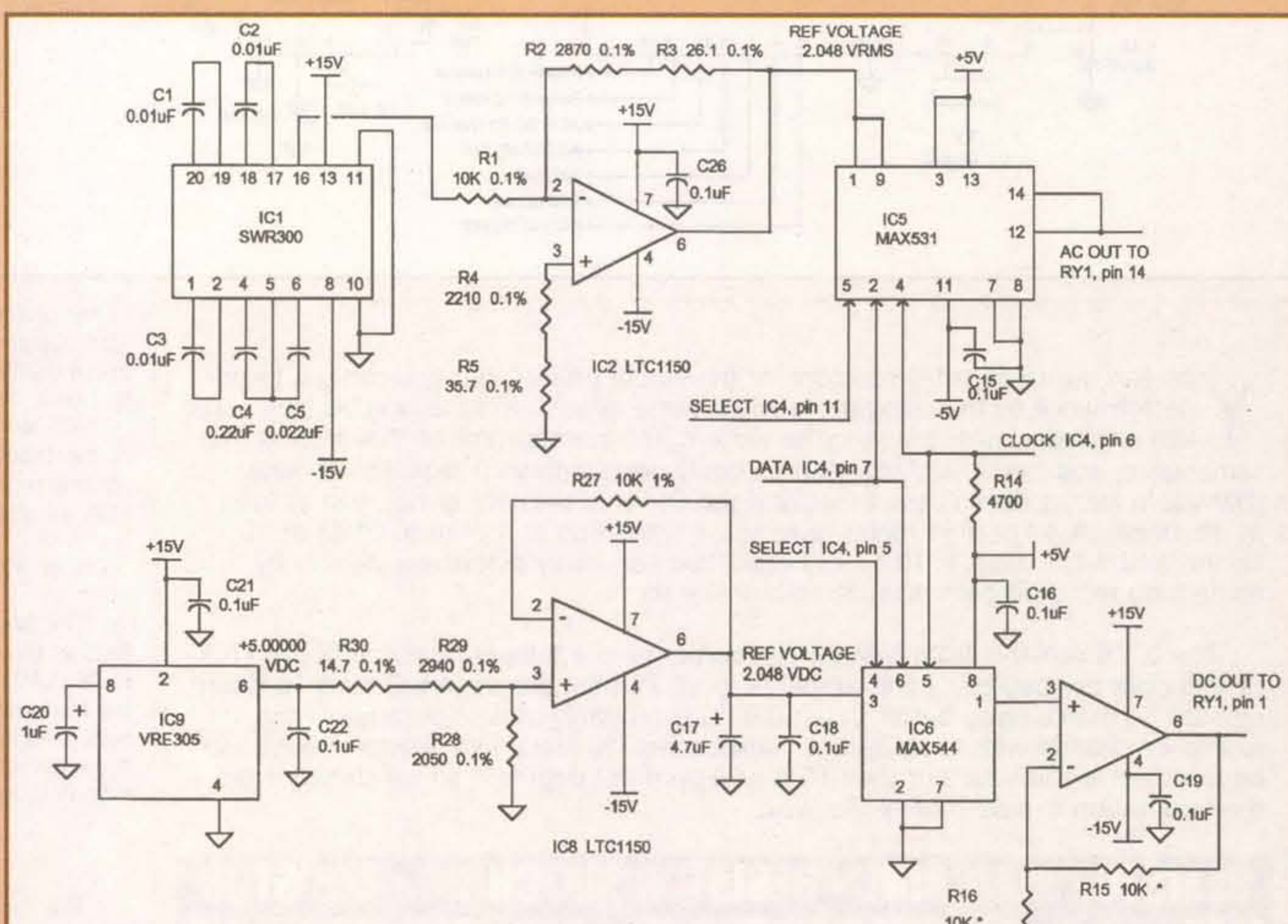


Figure 1. AC and DC Reference Supplies and DACs
DACs are programmed in parallel, but only one has its chip select enabled.

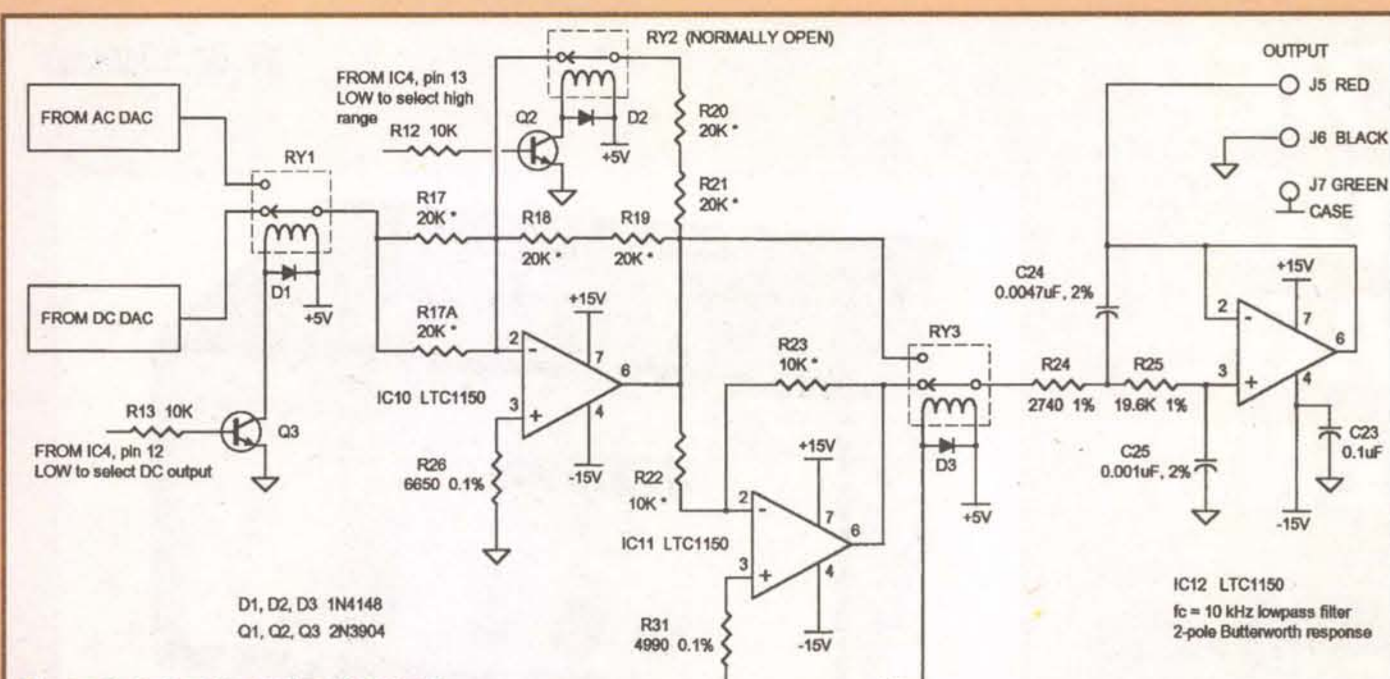


Figure 2. Relay Control and Output Lowpass Filter
The asterisks by the resistor values indicate matched sets — see sidebar.

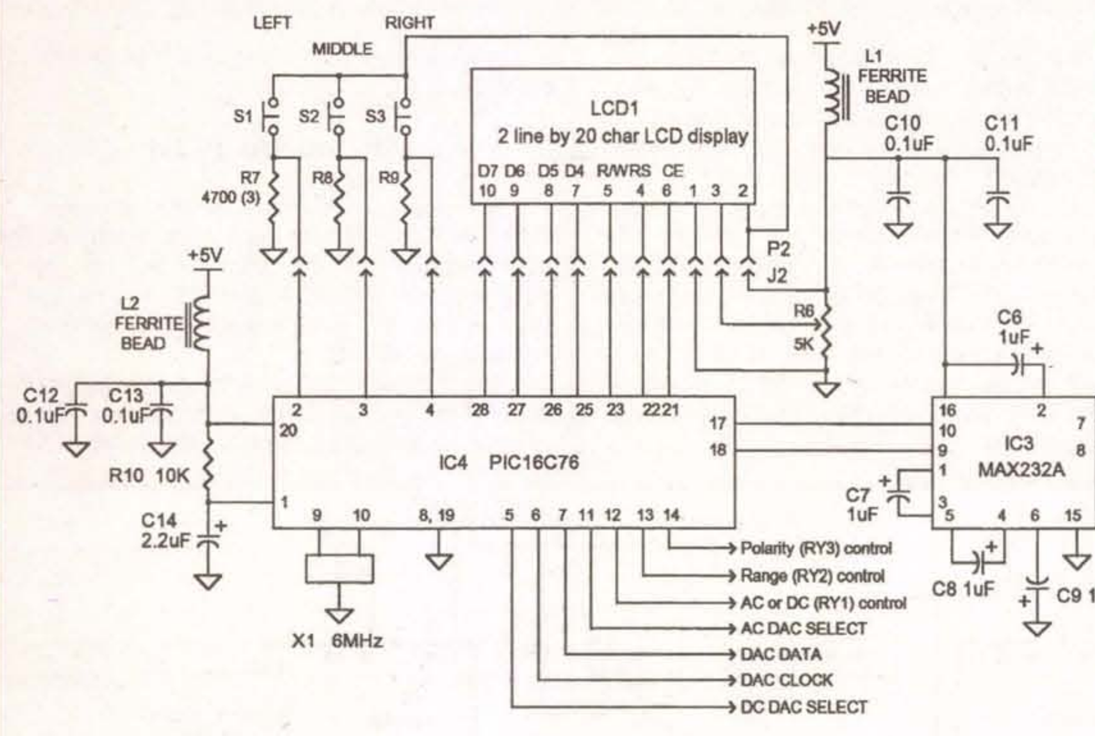


Figure 3. Microprocessor and RS-232 Transmitter/Receiver
L1 and L2 are ferrite beads — see text and parts list.

and S2 (Figure 3). Pushing S1 subtracts "one" from the count; pushing S2 adds "one." Every time the count changes, the program sends the new count to both DACs and updates the LCD display. Although both DACs get the count, only one of them responds; the one with its chip select enabled. In this case, the DC DAC.

The DC DAC is a Maxim MAX544, a 14-bit device used in this circuit as a 13-bit converter. Its output voltage:

Vout = (count / 8192) * Vref

Vref is 2.048 volts so the DAC output varies from zero to 1.250 volts as the count varies from zero to 5000. The DAC drives op-amp IC7 which has a non-inverting gain of two, so its output varies from zero to 2.500 volts.

When the Model 306 is set to DC LOW range, IC10 has a gain of two so the instrument output varies from zero to ±5.000 volts in 1-mV steps. On DC HIGH range, IC10's gain is four for an output of zero to ±10.000 volts in steps of 2 mV.

We can get pretty good performance by using standard 0.1% resistors to set op-amp gains, but we can do even better. For integer gains, resistor matching can reduce the gain uncertainty by 10 or more, depending on the resolution of your digital multimeter — see the Sidebar.

AC SIGNAL PATH

IC1 (Figure 1) is a Thaler Corporation SWR300 AC voltage reference producing a sinewave output of 7.071 volts RMS at a frequency set by its external capacitors C1 and C3. In this circuit, the frequency is set to 1000 Hz ±2%. Op-amp IC2 is connected to have a gain of about 0.2896 to reduce the AC reference voltage to 2.048 volts RMS for the AC DAC, IC5.

IC5 is a Maxim MAX531, a 12-bit converter connected for four-quadrant multiplication. This scheme produces a bipolar AC output with an RMS amplitude proportional to the digital count.

Vout = (count / 2048) * Vref

The DAC output varies from zero to two volts RMS as the count goes from zero to 2000. When in AC LOW range, IC10 still has a gain of two, so the instrument output varies from zero to 4.000 volts RMS in 2 mV steps. AC HIGH range doubles these numbers for a maximum output of 8.000 volts RMS in 4 mV steps.

MICROPROCESSOR

The microprocessor is a Microchip Technology, Inc., PIC16C76. It monitors the three front panel push-button switches, increments and decrements the DAC counter, changes menus,

RESISTOR MATCHING • RESISTOR MATCHING • RESISTOR MATCHING • RESISTOR MATCHING • RESISTOR MATCHING

You can use stock 0.1% resistors for the whole project, but you can get better performance by matching them when same-valued pairs are needed (see parts list). In these cases, the absolute value is not as important as their having the same value, and this "matching" can be easily done with your digital multimeter (DMM). In fact, it doesn't even matter if the DMM is accurate or not, just as long as it's stable. A 4-1/2 digit meter gives you a resolution of 1 ohm (0.01%) at 10 Kohms and 5-1/2 digits is 10 times better. You can easily determine stability by rechecking matched pairs after 30 minutes or so.

The 0.1% resistors from Mouser Electronics have a temperature coefficient (TC) of ±25 ppm per degree C. This amounts to ±0.25 ohm per degree C for a 10 Kohm resistor. So matching to better than ±0.01% is probably useless because of the resistance change with temperature. Inexpensive 1% metal film resistors could also be matched in this way, but their TC is ±50 ppm per degree C so we should avoid the temptation to save money this way.

programs the DACs, and manages the LCD display. It also sends the current settings (voltage, range, and mode) to an RS-232 transmitter (IC3) in "broadcast" mode. That is, the setting information is always available to an external device (computer) without any "handshaking." The PIC will also accept programming data from a computer over the RS-232 serial line. The control software is freely available, you can download the current versions (MS-DOS and Windows) from our web site.

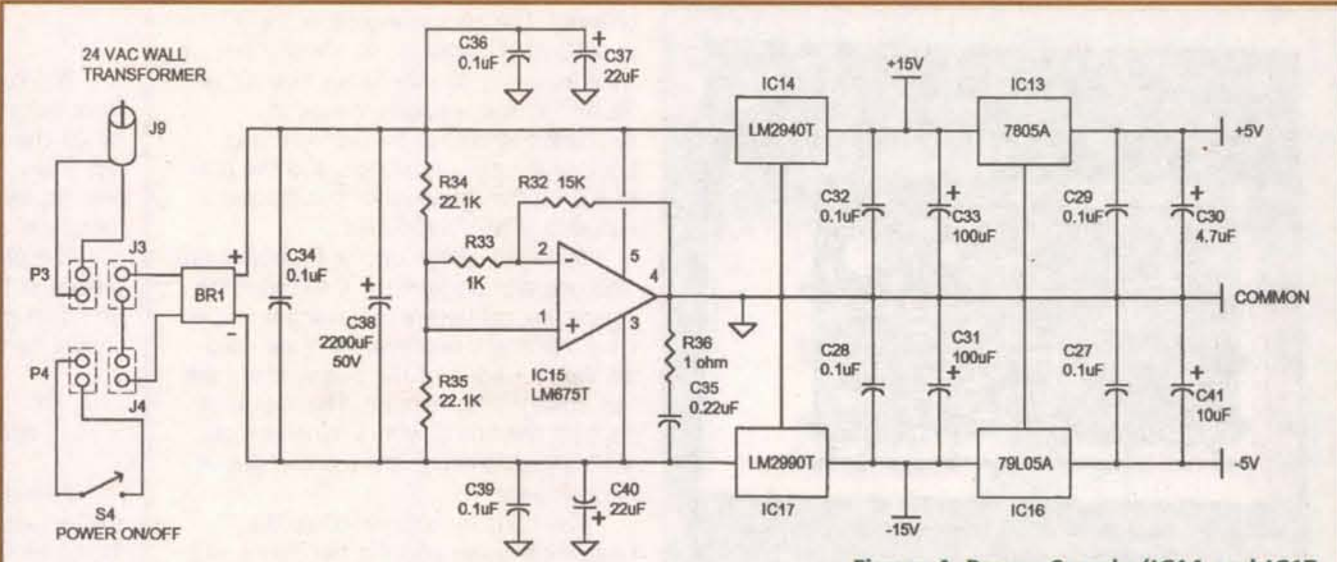


Figure 4. Power Supply (IC14 and IC17 are low dropout regulators.)

POWER SUPPLY

All operating power is derived from a 24-volt AC "wall wart" transformer. After rectification in diode bridge BR1 (Figure 4), the filtered DC power is "voltage split" by power op-amp IC15. The result of the split is about ±17 volts into the low dropout 15-volt regulators, IC14 and IC17. The positive regulators (IC13 and IC14) along with the power op-amp are attached to a "heatsink" for cool operation. Enhanced heat dissipation isn't needed for the lightly loaded negative voltage regulators.

Operation on 24-volts AC was chosen over using full AC line voltage because the lower voltage reduces 60 Hz and 120 Hz feed through on the reference output to very low levels.

CONSTRUCTION

All components, except for the switches and display, are on one double-sided circuit board (see Figure 5 photo). The PIC microprocessor is the only IC in a socket as this makes firmware updates easier. Parts locations are shown in Figure 6, and Figure 7 is a detail of connector J2 which connects the main circuit board to the front panel.

If you want to make your own PC board, you can download the artwork in CIRCAD and PDF formats from our web site. It's included in the file MAKE306.ZIP which also contains front and rear panel hole layout drawings.

The order of placing parts on the board is your choice, but I've found it more convenient to add all the ICs and relays first and then place the other components around them. If you have made your own PC board (without plated through holes), don't forget that some of the IC pins and other component leads will also have to be soldered on the top side.

Even though most of the ICs are somewhat expensive, DON'T use sockets (except for the PIC). The added and variable contact resistance will degrade the accuracy and long term stability. It's also important to use solder from the same roll for the whole board as this too can affect output voltage accuracy.

The power op-amp (IC15) and the two positive voltage regulators (ICs 13 and 14) attach to the rear panel with a short length of aluminum

PARTS LIST

RESISTORS	
R1	10K, 0.1%, 1/4W metal film
R2	2870, 0.1%, 1/4W metal film
R3	26.1, 0.1%, 1/4W metal film
R4	2210, 0.1%, 1/4W metal film
R5	35.7, 0.1%, 1/4W metal film
R6	5K, turn trim pot
R7, R8, R9, R14	4700, 5%, 1/4W carbon film
R10, R27	10K, 1%, 1/4W metal film
R11, R12, R13	10K, 5%, 1/4W carbon film
R15 and R16	10K, 0.1%, 1/4W metal film matched to ±0.01%
R17, R17A, R18, R19	
R20, R21	20K, 0.1%, 1/4W metal film matched to ±0.01%
R22 and R23	10K, 0.1%, 1/4W metal film matched to ±0.01%
R24	2740, 1%, 1/4W metal film
R25	19.6K, 1%, 1/4W metal film
R26	6.65K, 0.1%, 1/4W metal film
R28	2050, 0.1%, 1/4W metal film
R29	2940, 0.1%, 1/4W metal film
R30	14.7, 0.1%, 1/4W metal film
R31	4990, 0.1%, 1/4W metal film
R32	15K, 1%, 1/4W metal film
R33	1K, 1%, 1/4W metal film
R34, R35	22.1K, 1%, 1/4W metal film
R36	1 ohm, 5%, 1W carbon film
CAPACITORS	
C1, C3	0.01 uF, 2%, polypropylene film
C2	0.01 uF, 5%, metalized film
C4, C35	0.22 uF, 5%, metalized film
C5	0.022 uF, 5%, metalized film
C6, C7, C8, C9, C20	1 uF, 35V tantalum electrolytic
C10, C11, C12, C13, C15	
C16, C18, C19, C21, C22	
C23, C26, C27, C28, C29	
C32, C34, C36, C39	0.1 uF, 50V ceramic
C14	2.2 uF, 25V tantalum electrolytic
C17, C30	4.7 uF, 25V tantalum electrolytic
C24	0.0047 uF, 2%, metalized film
C25	0.001 uF, 2%, metalized film
C31, C33	100 uF, 50V, low ESR electrolytic
C37, C40	22 uF, 25V, tantalum electrolytic
C38	2200 uF, 50V, electrolytic
C41	10 uF, 25V tantalum electrolytic
SEMICONDUCTORS	
BR1	1A, 50V bridge rectifier
D1, D2, D3	1N4148 silicon diode
Q1, Q2, Q3	2N3904 NPN transistor
IC1	SWR300CD Thaler Corp. AC voltage reference
IC2, IC7, IC8, IC10, IC11	
IC12	LTC1150-CN8 chopper op-amp
IC3	MAX232A +5V RS-232 driver/receiver
IC4	Microchip PIC16C76 programmed with the operating firmware
IC5	MAX531ACPD 12-bit serial multiplying DAC
IC6	MAX544ACPA 14-bit serial DAC
IC9	VRE305A Thaler Corp. +5V DC voltage reference
IC13	7805A +5V regulator
IC14	LM2940CT +15V low dropout regulator
IC15	LM675T power opamp
IC16	79L05A -5V low power regulator
IC17	LM2990CT -15V low dropout regulator
OTHER COMPONENTS	
L1, L2	1206 surface mount ferrite bead, R = 0.8 ohm max, Z = 600 ohms at 100 MHz (Digi-Key P10189CT or equal)
RY1, RY3	SPDT reed relay, 5V coil, coil resistance 200 ohms or higher. Hamlin HE-112 (Digi-Key) or equal. Note that not all SPDT reed relays have the same "footprint".)
RY2	SPST reed relay, 5V coil, coil resistance 400 ohms or higher
X1	6 MHz ceramic resonator with built-in capacitors
J1	3-pin 0.1 inch header (Molex 22-03-2031 or equal)
J2	2, 7-pin 0.1 inch headers, side-by-side (Molex 22-03-2071 or equal)
J3, J4	2-pin 0.1 inch header (Molex 22-03-2021 or equal)
J5	Binding post, red
J6	Binding post, black
J7	Binding post, green
J8	Panel mount, female DB9 connector
J9	DC power jack, insulated, to mate with connector on the 24 VAC Wall transformer
P1	3-pin terminal housing with pins (Molex 22-01-2037 or equal)
P2	2, 7-pin terminal housing glued side-by-side (Molex 22-01-2077 or equal)
P3, P4	2-pin terminal housing with pins (Molex 22-01-2027 or equal)
T1	Wall transformer, output 24 VAC, 500 mA or higher
LCD1	20 x 2 LCD display (photos and pin numbers are for a BG Micro LCD1005)
S1, S2, S3	High-rel normally-open push-button switch (Mountain Switch 10PM021 or equal)
S4	Miniature SPST toggle switch
Cabinet, SESCOM Inc., type MC-9A	
Circuit board, ACDC306, rev 1B	
Front panel, etched aluminum	
1/2 x 3/4 x 2-3/8 inch aluminum channel heatsink	
LCD to circuit board cable assembly, one 10-pin header, one 10-pin housing with pins and wire	
One 18-pin DIP socket for PIC16C76 (IC4)	
Hardware, including two 3/8 inch long hex spacers, two 3/8 inch long nylon PCB posts, machine screws, nuts, washers, etc.	

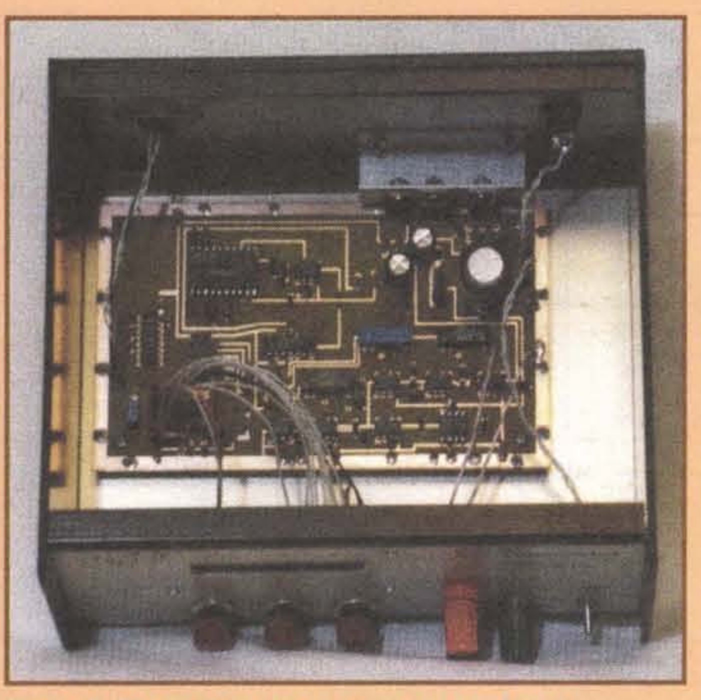


Figure 5. Photo showing the circuit board and heatsink bracket. Connect the reference voltage output pads directly to the front panel binding posts with 4-1/4 inch lengths of #22 or 20 AWG wire.

channel. The +5 volt regulator is available in a TO-220F package, so it won't need a mica insulator, but the other two ICs will. Be sure to use a small amount of heatsink compound on the front and back of the mica insulators and the back of IC15. (The drawing for this bracket is included in MAKE306.ZIP.)

Surface leakage on the PC board can also degrade performance, so clean the solder flux off before mounting it in the case. Although two standoffs are used on the rear edge of the board, these are not attached to the case. The idea is to support the board with a minimum of mechanical stress as this too can degrade performance.

The board is supported by the heatsink bracket and the two front edge standoffs which are nylon snap-in posts. These attach with a screw to the bottom plate of the cabinet, but just snap into the oversize holes in the circuit board.

The reference is ready to use "as built." There are no calibration adjustments and the only control is R6 which sets the LCD display contrast.

OPERATION

You control the model 306 with the three front panel push-button switches and the two-line by 20 character LCD display. The bottom display line shows the push-button labels while the top line displays the output voltage, range (high or low), and mode (AC or DC).

The microprocessor firmware initializes the output at turn-on to low range DC with an output of 2.500 volts (which is mid scale). The LCD shows the following:

DC LOW 2.500 V
1 mV DOWN UP MENU

Pushing the left button (DOWN) decreases the output by 1 mV, and the center button (UP) increases the output by 1 mV. Pressing and holding either button starts continuous stepping at about five steps per second.

Push the MENU button once and the voltage step size increases to 100 mV (0.1V).

Pushing the MENU button again puts the model 306 into programming mode and lets you select either low or high output range. The display shows:

DC LOW 2.500 V
LOW HIGH MENU

The left button selects LOW range and the center button selects HIGH. For example, if you press the center button, the top display line changes to "DC HIGH 5.000 V" but you are still in programming mode until you get back to a bottom line that reads "X mV DOWN UP MENU" (where "X" depends on the range and mode). If you don't make a new menu selection, the settings shown on the top line stay in effect.

So press the MENU button again. Now you have a choice of AC or DC output. If you want to stay in DC mode, just push MENU again. To change to AC mode, push AC and then MENU. Now you have a choice of positive (POS) or negative (NEG) output voltage. Make a selection or just push MENU to exit programming mode and re-enter operating mode.

The minimum voltage step size depends on the range and mode. DC low range has 1 mV steps and this increases

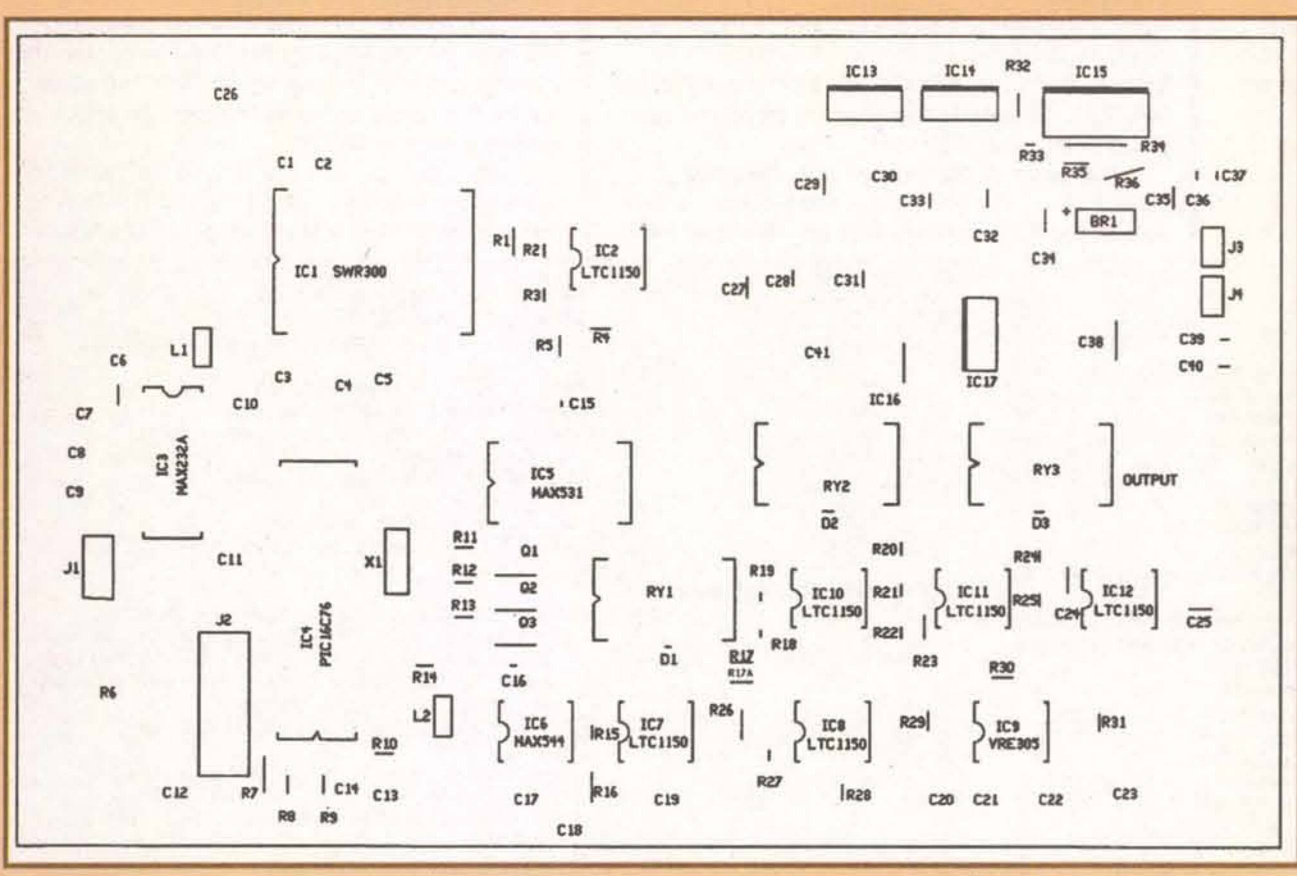


Figure 6. Model 306 Parts Location

RESOURCE LIST

Most of the components including the chopper op-amps and DACs are available from **Digi-Key Corporation**, P.O. Box 677, Thief River Falls, MN 56701; 1-800-344-4539, or www.digikey.com.

The 1% and 0.1% metal film resistors can be ordered from **Mouser Electronics**, 958 N. Main St., Mansfield, TX 76063; 1-800-346-6873 or on-line at www.mouser.com.

JAMECO (1355 Shoreway Rd., Belmont, CA 94002) stocks the LM675T power op-amp at a good price. Call 1-800-592-8097 or on-line at www.jameco.com.

The DC and AC reference ICs are from **Thaler Corporation**, 2015 N. Forbes Blvd., Tucson, AZ; 1-800-827-6006. (They accept small orders.)

The MC-9A aluminum enclosure is available from **SESCOM, Inc.**, 2100 Ward Dr., Henderson, NV 89015-4249; 1-800-634-3457.

I bought the two-line by 20 character LCD display from **BG Micro**, P.O. Box 280298, Dallas, TX; 1-800-276-2206 or www.bgmicro.com. It's their catalog number LCD1005, but most any display with an HD44780 controller chip should work as well.

PC board artwork, panel drilling drawings, front panel artwork, and the microprocessor hex file can be downloaded from our web site at www.zianet.com/tdl. Click on Magazine Article Reprints and then click "make306.zip" to download. After unzipping, read "contents.txt" for an explanation of the other files. The double-sided PC board, programmed 16C76, and an etched aluminum front panel are available from TDL Technology, Inc., 5260 Cochise Trl., Las Cruces, NM 88012. Voice 505-382-3173, FAX 505-382-8810 or visit our web site for details.

TOP VIEW

PIC B2 (R/W) --> LCD pin 5	O	O	No connection
PIC B1 (R/S) --> LCD pin 4	O	O	PIC B4 (data 4) --> LCD pin 7
PIC B0 (CE) --> LCD pin 6	O	O	PIC B5 (data 5) --> LCD pin 8
COMMON --> LCD pin 1	O	O	PIC B6 (data 6) --> LCD pin 9
Contrast adj. --> LCD pin 3	O	O	PIC B7 (data 7) --> LCD pin 10
+5 volts --> LCD pin 2	O	O	PIC A2 --> right pushbutton
PIC A0 --> left pushbutton	O	O	PIC A1 --> middle pushbutton

Figure 7. J2 Detail, Main Circuit Board to Front Panel
Use five-inch length wires from this connector to the front panel.

to 2 mV on DC high range. AC low range has 2 mV steps and AC high range is 4 mV. The difference between the DC and AC voltage step size is due to the resolution of the digital-to-analog converters (DACs). The DC DAC is a 14-bit converter (operating at 13-bits) and the AC DAC is 12-bits (actually 11-bits due to connection as a four-quadrant multiplier).

The red binding post is DC positive when POS polarity is chosen and DC negative for NEG polarity. The black post is connected to circuit board common and the green post connects to the case. There is no internal connection between circuit common and the case. An external connection between the black and green posts may reduce noise or 60 Hz on the output, depending on your application.

SOFTWARE

An MS-DOS "C" program and a Windows Visual Basic program are available to display the current output settings and to control the model 306 over an RS-232 serial connection. The rear panel DB9 connector is used to connect the reference to a PC's serial port, either COM1 or COM2 can be selected.

Both versions of the control program are menu driven and allowable ranges of input parameters are shown on the screen (and checked by the software!). You can program a sequence of DC or AC voltage steps and step duration with a minimum duration of 10 milliseconds.

To use the software, connect the serial cable, turn on the model 306, and then start the program. The output settings will be displayed. Follow the on-screen instructions to enter programming mode.

FUTURE PLANS

This instrument's operation is controlled by the firmware in the microprocessor, so it's fairly easy to add new features. For example, a future firmware version will let you set the AC output in 1 dB steps relative to 1V RMS. Another possibility is simulating the output voltage of one or more thermocouple types using temperature as the displayed variable. **NV**

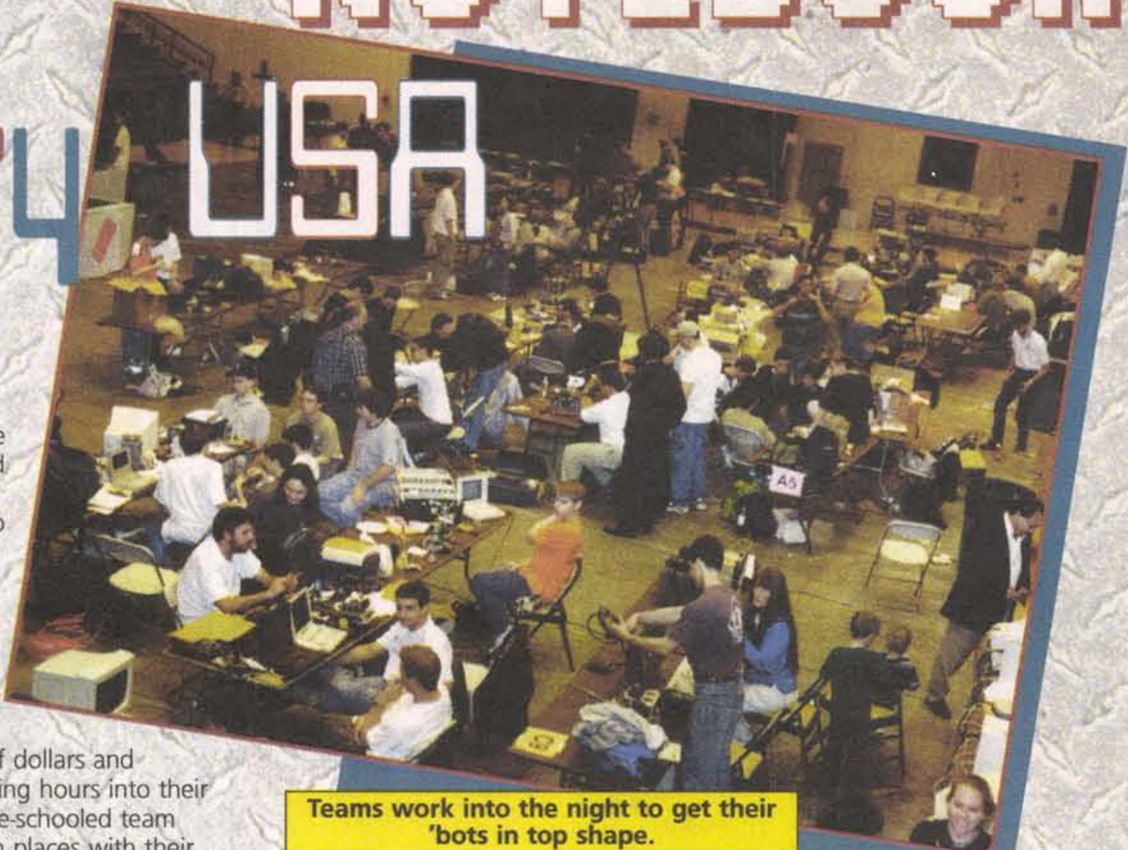
Check out Ron's original AC-DC voltage reference article in the January 2000 issue of *Nuts & Volts*.

Figure 8. Photo showing the LCD display which is attached to the front panel with four 2-56 x 1/2 inch machine screws, nuts, and 1/4 inch long spacers. Place a nylon washer between the spacer and LCD board for insulation and to add 1/16 inch to the spacer length. The rear panel shows the power input connector on the left and serial DB9 on the right.

AMATEUR ROBOTICS NOTEBOOK

by Robert Nansel

Robot City USA



Teams work into the night to get their 'bots in top shape.

It is April 15th, 2000, and I'm at Trinity College in Hartford. The air in the gymnasium where the Seventh Firefighting Home Robot Contest robot contest will be held is thick with anticipation. There are teams from all over the world: from Argentina, Australia, Canada, Israel, France, Switzerland, Palestine, and the Republic of Korea.

From the United States, teams hail from Arkansas, Colorado, Connecticut, Georgia, Illinois, Indiana, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Oklahoma, Pennsylvania, Rhode Island, Texas, Vermont, and Virginia.

It's late on Saturday night, the competition is tomorrow, and most of the teams have been working on their machines all day.

This is my fourth time at Trinity, and this time, it's bigger than all expectation, continuing the trend since the contest first began seven years ago. Last year, there were 73 robots entered, not all of which qualified; a robot has to demonstrate it can put the candle out at least once in order to even compete.

This year, there are 130 entrants and 81 qualifiers. It is distinctly more crowded than last year; there is no way I can talk with everybody, and I love it. This is the largest robotics competition in the United States, and it is open to anyone who wants to give it a shot, ranging from a home-schooled brother and sister team to professional engineers who pour thousands of dollars and as many engineering hours into their entries. (The home-schooled team took 6th and 11th places with their two entries in the Junior division.)

Gearheads young and old work on their 'bots at folding banquet tables. The gymnasium floor is protected by a patchwork of giant plastic tarps joined together with duct tape, and over the tarps power cables snake along the floor from two large power distribution panels on one side of the gym to each of the tables, forming a temporary power distribution tree worthy of a small town. Robot City, USA. They haven't blown any breakers. Yet.

The contestants rub their eyes and squint up at the high-pressure sodium vapor lights that play hob with their infrared sensors. They tweak a pot, make readings on oscilloscopes and meters, and squint some more at the wires, metal, plastic, and hot glue their machines are made of.

The night before the competition the mazes get crowded with teams doing last-minute runs.

Loud Music and Legos

One end of the gymnasium is dominated by younger student teams; the teams from Israel, and the teams from American high schools and technical schools. It is a place of raucous music played on laptop CD-ROM drives, of tiny MP3 players, of teens sprawled on the floor programming with laptops and notebooks. Likewise, there are the Lego people surrounded by plastic trays of Lego bricks and spools of wire.

In one corner, a young man works on a desktop PC; the tower case of the PC is custom-made out of clear acrylic. Inside the see-through case, he has installed a black light tube. He's painted the ribbon cables with fluorescent green paint, and the whole machine glows.

The music gets louder later into the night.

None of the teams want to call it a night, though most of them are already haggard from too little sleep and too much travel. All are convinced that just a little last minute tweaking will give them an edge — or make a hopeless robot function.

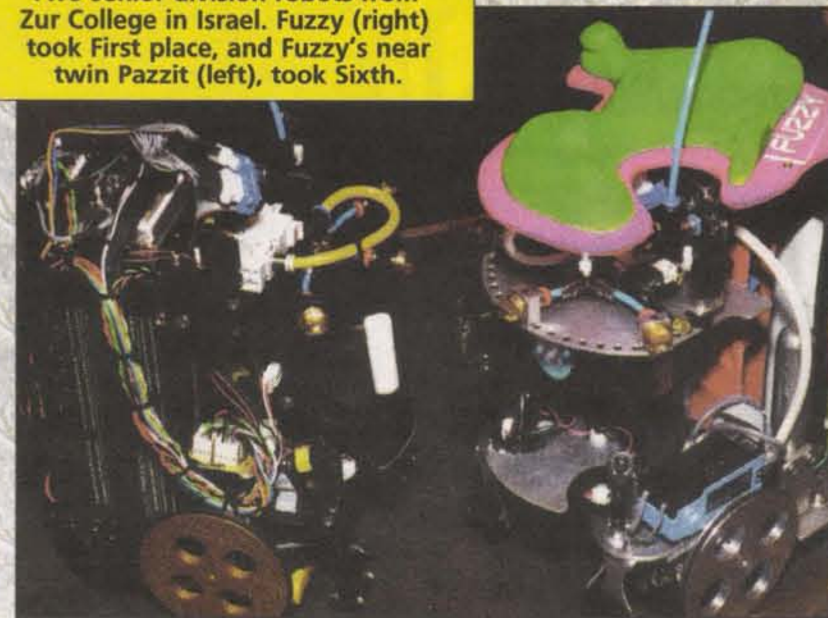
Steve Richards of Acroname, one of the seminar speakers, said of gearheads that they must have backgrounds in mechanical engineering, electronic engineering, software engineering, and optimism. Every gearhead here brings a different mix of strengths and weaknesses in these areas, but every one of them is strong on optimism. The glass is not just half-full here, it's overflowing.

The Results

Tables 1 and 2 show the top four for the junior and senior divisions. Continuing the trend I noted last year, the time ratio between first and sixth place in the senior division tightened again this year. In '98, the first place senior division robot was 3.1 times faster than the sixth place, last year the ratio had dropped to 3.0, and this year it dropped again to 2.5. The senior division is showing the first signs of approaching performance limits. Granted, it will be a number of years before the scores in the top six will differ only by fractions of a second, but it is on the horizon.

This prompted many discussions during the competition on how the

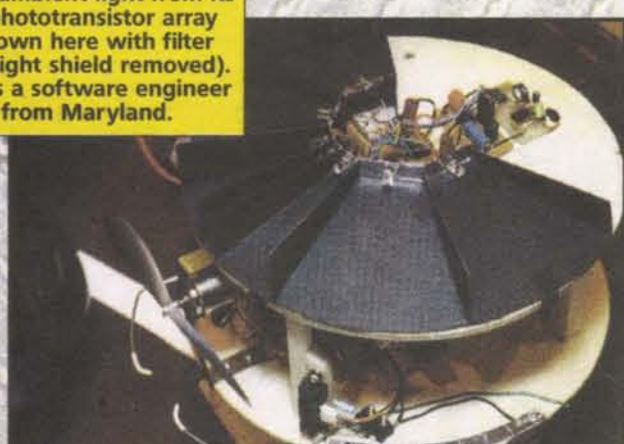
Team from New Mexico Tech, Fourth place, senior division.



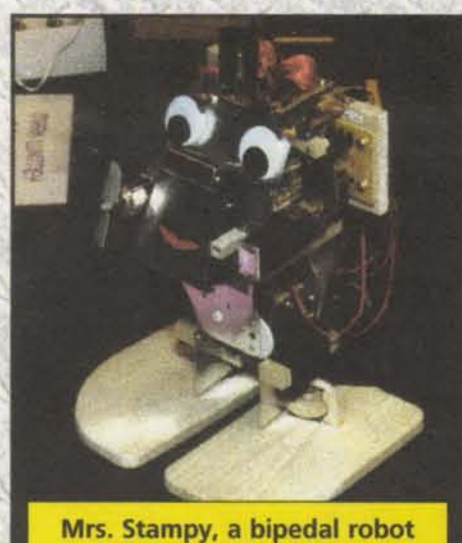
Two senior division robots from Zur College in Israel. Fuzzy (right) took First place, and Fuzzy's near twin Pazzit (left), took Sixth.

Second place senior division winner Julie Wiens from New Mexico Tech with her robot Mr. K1.

Jonathan Fink from North Penn High School in Pennsylvania, Second place, junior division.



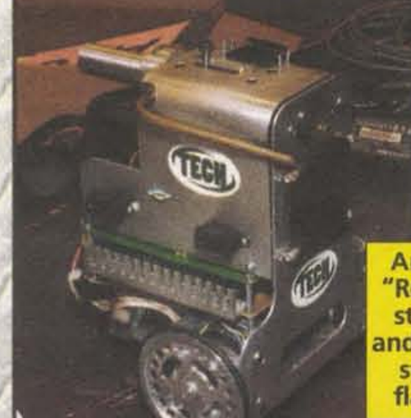
Nomad, the creation of Jim Cannaliato, used strips of anti-static bag material to filter ambient light from its IR phototransistor array (shown here with filter and light shield removed). Jim is a software engineer from Maryland.



Mrs. Stampy, a bipedal robot built by Mark Whitney.
Mrs. Stampy only placed 34th, but was a crowd favorite. Whitney is a software engineer from North Carolina and a member of the Triangle Amateur Robotics Group.

Scott Boynton from East Granby High School in Connecticut, Fourth place, junior division.

Team from Herzlia Hebrew Gimnasia in Israel, First place, junior division.



Arkansas Tech's "Rocketeer" used stepper motors and a unique blind system for the flame detector.

Photos by Robert Nansel and Joan Walden

contest should be modified to make it just a little bit more difficult, at least as an optional operating mode. One suggestion I liked was the idea of introducing patches of carpet in some of the rooms, or perhaps in the corridors. This would force more thoughtful navigation schemes and make the contest — as a whole — a more realistic simulation of the environment a firefighting robot would face in the real world.

The junior division competitors also continued their trend toward closing the gap between senior and junior divisions. Last year, the first place junior division robot would still have been beaten by the senior division sixth place, but this year, the juniors would have beaten the fifth place senior entry.

The biggest surprise this year, though, was how strong the Israeli teams were. Last year was their first time competing at Trinity, and they were — quite frankly — blown out of

U.S. Robot Groups

Region: Phoenix, AZ
Group name: Phoenix Area Robotics eXperimenters (PAReX)
Contact: Mike Reiner, president
Email: k6zwc@cds1.net
URL: www.web-robots.com/parex, www.botbash.com
Meetings: 1st Friday of the month, Location info on web site
Address:
Telephone:

Region: Russellville, AR
Group Name: Arkansas Tech University IEEE student branch
Contact: Dr. Murray Clark
Email: murray.clark@mail.atu.edu
URL: engr.atu.edu/Projects/engr/EGR_HME.htm
Meetings:
Address: Murray Clark
ATU Engineering Dept.
Highway 7 North
Russellville AR 72801
Telephone: (501) 964-0876

Region: Anaheim CA
Group Name: Robotics Society of Southern CA
Contact: Art LeBouthillier
Email: apendragn@earthlink.net
URL: home.earthlink.net/~apendragn/rssc
Meetings: 2nd Saturday of month at room EE321
California State University Fullerton
12:30-1:00 Business meeting
1:00-3:00 General meeting
Address: RSSC
P.O. Box 26044
Santa Ana, CA 92799-6044
Telephone:

Region: San Diego, CA
Group Name: SDRS - San Diego Robotics Society
Contact: Peter Cresswell
Email: peter.cresswell@funtv.com
URL: www.eGroups.com/group/sdrs-list
Meetings: 1st Saturday at ITT Techical Institute, San Diego,
9AM - 12PM General meeting
Address:
Telephone:

Region: San Jose, CA
Group Name: Palo Alto Homebrew Robotics Club
Contact: Bill Benson
Email: wbenson@ibm.net
URL: www.geocities.com/homebrewrc
Meetings: last Wednesday of each month
(no meeting in Dec)
held at 7:30 PM, library of Castro Middle School
Address: Castro Middle Scool
4600 Student Lane
San Jose, CA 85130
Telephone: (408) 874-3300

Region: San Francisco, CA
Group Name: San Francisco Robotics Society of America
Contact: Roger Gilbertson
Email: SFRSA@mondo.com
URL: www.robots.org
Meetings: 1st Wednesday, 7:30 PM at the San Francisco Exploratorium
Address: 3601 Lyon Street
San Francisco, CA 94123
Telephone: (415) EXP-LORE

Region: Aurora, CO
Group Name: Rockies Robotics Group
Contact: Frank Arteseros
Email: kiko2@ix.netcom.com
URL: http://www.rockies-robotics.com
Meetings:
Address:
Telephone:

Region: Colorado Springs, CO
Group Name: Pikes Peak Robotics Group
Contact: Jay Snively
Email: pprg@pcisys.net
URL: www.pcisys.net\~phantom\pprg.htm
Meetings:
Address:
Telephone:

Region: Hartford, CT
Group Name: Connecticut Robotics Society
Contact: Jacob Mendelssohn
Email: JMENDEL141@aol.com
URL: www.ctrobots.org
Meetings: 2nd Sunday of each month at 1 PM
Address:
Telephone:

Region: Atlanta, GA
Group Name: Atlanta Hobby Robot Club
Contact: C. Barry Ward, president
Email: cbward@abraxis.com, robotclub@idea-vision.com
URL: www.botlanta.org
Meetings: 10:00 AM on the Last Saturday of each month
Address: Radioshack.com
5600 Buford Hwy NE
Doraville, GA. 30340
Telephone: (770) 663-3420

Region: Peoria, IL
Group Name: Central Illinois Robotics Club
Contact: Jim Munro
Email: jimmn@xnet.com
URL: www.circ.mtco.com/
Meetings: 3rd Sunday of month (except Holidays) @ 1:00 PM
Address: Lakeview Museum of Arts & Sciences
1125 West Lake Avenue
Peoria, IL 61614-5985
Telephone: (309) 686-7000

Region: ISU, IA
Group Name: Iowa State University Robotics Club (ISURC)
Contact: Dr. Ralph Patterson
Email: repiii@iastate.edu
URL: www.ee.iastate.edu/~cybot/
Meetings:
Address:
Telephone:

Region: Wichita, KS
Group Name: Wichita Robot Club
Contact: Laris Pickett, president (lpickett@ontargetusa.com)
Tom Light VP, (tlight@club-net.org)
Greg Carpenter (WfU@compuserve.com)
Email: help@robot-club.org
URL: kansas.robot-club.org/
ourworld.compuserve.com/homepages/wfu
Meetings:
Address: 1730 Charleston
Wichita, KS 67219-1609
Telephone: (316) 744-8600 (voice)
(316) 744-3030 (fax)

Region: Minneapolis, MN
Group Name: Twin Cities Robotics Club
Contact: Rand Whillock (whillock@htc.honeywell.com)
Email: tcrobots-request@orbis.net
URL: www.tcrobots.org/
Meetings: 3rd Thursday of each month, 7 to 10 PM
Science Museum of Minnesota in St. Paul
Address:
Telephone: (612) 404-2009

Region: University City, MO
Group Name: Missouri Area Robotics Society
Contact: Bob Bailey
Email: baileys@ktis.net
URL: http://walden.mvp.net/~rickmoll/mars/
Meetings: 3rd Saturday at 10:00 AM
(except in Jun, Jul, Aug, & Dec)
University City Library Auditorium
Address: 6701 Delmar Boulevard
University City, MO
Telephone:

Region: Nashua NH
Group Name: Nashua Robot Builders Club
Contact: Quentin Lewis
Email: bigqueue@tiac.net
URL: www.tiac.com/users/bigqueue/others/robot/homepage.htm
Meetings: 1st Wednesday of the month at 7 PM
Hunt room at Nashua Public Library.
Address:
Telephone:

Region: Los Alamos, NM
Group Name: Northern NM Robotics Group
Contact: Mark Dalton
Email: mwd@cray.com
URL:
Meetings:
Address:
Telephone:

High GEAR Camping Info

Each campsite costs $30.00 ($6.00 non-refundable reservation fee + $12.00 per night x two nights). Four adults and one vehicle per campsite are covered by the $30.00. Additional adults and vehicles are subject to a per-night fee, $6.00 per night per vehicle. (There will be two adults and a toddler at our site, so two more brave souls are welcome to share the site. We can take a couple more, even. There's plenty of room in these sites for extra tents.)

Check in is 2:30 p.m. on July 28 and checkout is 1:00 p.m. July 30. If you want to arrive earlier or leave later, you will need to contact the Reservations Northwest people (1-800-452-5687). If you have questions the reservation people can't answer, you might also try the park itself at (360) 331-4559.

The sites I've reserved are on the lower loop, numbers 11, 12, and 13. They overlook Puget Sound and are not far from the restroom and shower facilities. The sites do not have hookups, but there are hookup sites in the park. If you need one, call now to reserve one.

A word to the wise: They sell "firewood" at the park, but it's usually freshly cut Alder that sizzles (as in wet steam) when you attempt to burn it; bring your own wood or buy bundles at the grocery store after you get off the ferry. I'll give ferry schedule and driving directions next month.

Not everybody needs to camp out to participate; it's perfectly fine to just make it a day trip and hang out with the campers if you can't take the whole weekend. There are also many nearby bed-and-breakfast establishments for those non-campers among you.

the water. This year, they got their revenge, taking both the junior and senior division first place prizes. Moreover, the Israelis also took third in the junior division, and sixth in the senior division.

I can't wait for next year. It's time for me to build a new robot, a robot for competition, perhaps a firefighter. Over the next year, I will present the complete, clean-slate design as it evolves. I'll show you all the circuits and mechanical details, and the software will be Open Source so anyone can duplicate it, or even better it (that would truly delight me).

The Beginnings of a New Robot

The first decision you have to make when designing a new robot is what it will do. It's true, I have on occasion begun robot projects with only the vaguest notion what the robot would do, but my most successful robots have all had a basic plan. Breadbot (first covered in the June and July '98 issues of this magazine) came out of the desire to create a beginner's robot that was low-cost, simple to build, and very flexible. As to what it would "do," it was meant to be educational, to introduce the first-time homebrew robot builder to the inter-related problems of mechanics, electronics, and programming that any robot design must solve.

Breadbot's design accomplished this by combining the chassis and circuit-wiring functions in the form of a standard solderless breadboard. The initial design used a BASIC Stamp 1 from Parallax to simplify wiring and programming, and it employed modified hobby servos for propulsion.

But the key to Breadbot's design was that all components attached either to the underside of the breadboard (using the breadboard's own double-sticky mounting foam) or

U.S. Robot Groups continued

Region: Long Island, NY
Group Name: Long Island Amateur Robotics Club
Contact:
Email: Rich924@aol.com
URL: members.aol.com/rich924/html/meetinfo.html
Meetings:
Address:
Telephone:

Region: Schenectady, New York
Group Name: Union College Robot Club
Contact:
Email: robot-club@vu.union.edu
URL: www.vu.union.edu/~robot/
Meetings:
Address:
Telephone:

Region: Raleigh, NC
Group Name: Raleigh Triangle Amateur Robotics Group
Contact: Russell Lyday, president, Alan Porter webmaster
Email: r.lyday@worldnet.att.net, alan.porter@ericsson.com
URL: http://triangleamateurrobotics.org/
Meetings: 7:30 PM on 1st Monday at Clark Labs Room 110, North Carolina State University
Address: 10 Clark Labs
North Carolina State University
Raleigh, NC
Telephone:

Region: Cleveland, OH
Group Name: Robo CWRU R&D Group
Contact: Joyce A Boone
Email: jab3@po.cwru.edu
URL:
Meetings:
Address:
Telephone:

Region: Troy, OH
Group Name: The Miami Valley Robotics Club
Contact: Jon Magin (jmagin@allegro.net)
Email: robots@bright.net
URL: www.activedayton.com/community/groups/robotclub/
Meetings: 7:00 PM on the first Tuesday of month at the Miami County Public Library
Address: 419 W. Main St
Telephone:

Region: Portland, OR
Group Name: Portland Area Robotics Society
Contact: Marvin Green
Email: marvin@agora.rdrop.com
URL: www.rdrop.com/users/marvin/
Meetings: First Saturday of each month at Mt. Hood Community College. Room #1277 at 10:30 AM
Address:
Telephone: (503) 666-5907

Region: Pittsburgh, PA
Group Name: CMU Robotics Club
Contact: Ryan Miller
Email: jmce@cs.cmu.edu
URL:
Meetings: (CMU students only)
Address:
Telephone:

Region: Pittsburgh, PA
Group Name: Pittsburgh Amateur Robotics Society
Contact: Robert Nansel
Email: bnansel@nauticom.net
URL:
Meetings: (TBD)
Address: P.O. Box 228
Ambridge, PA 15003
Telephone: (724) 266-8282

Region: Austin, TX
Group Name: The Robot Group
Contact: Alex Iles, Don Colbath
Email: robo@robotgroup.org, dcolbath@austin.rr.com
URL: www.robotgroup.org/
Meetings:
Address:
Telephone:

Region: Dallas, TX
Group Name: Dallas Personal Robotics Group
Contact: Clay Timmons, Kipton Moravec
Email: ctimmons@asic.sc.ti.com, kmoravec@airmail.net
URL: www.dprg.org/
Meetings:
Address:
Telephone:

Region: Seattle, WA
Group Name: Seattle Robotics Society
Contact: Ted Griebling, president
Email: president@seattlerobotics.org
URL: www.seattlerobotics.org/
Meetings: 3rd Saturday of every month Renton Technical College, room 314. 10 AM-12 noon.
Address: Seattle Robotics Society
P.O. Box 1714
Duvall, WA 98019-1714
Telephone:

Place	Score	Robot Name	Humans	School	Location
1	10.43	Rashmash	Noa Fish Ori Goshen Esti Levy Galia Buchbut Matan Bichcho Mor Zukervusser	Herzlia Hebrew Gimnasia	Israel
2	30.28	Beta	Jonathan Fink	North Penn HS	Pennsylvania
3	35.80	Alanis	Dana Gonczarowski Yaron Karmi Hagit Amzalek	Herzlia Hebrew Gimnasia	Israel
4	128.3	Thor	Scott Boynton	East Granby HS	Connecticut

Table 1: Junior Division — Top Four robots out of 28 qualified (21 non-quals.).

Place	Score	Robot Name	Humans	School/Organization	Location
1	5.16	Fuzzy	Yoav Rodan Roy Azriel Maya Shwarts Nadav Leshem Shahar Chiel Itamar Zisling	Zur College	Israel
2	7.26	MR. K1	Julie Wiens	New Mexico Tech	New Mexico
3	8.11	LC	Gary Teachout	Seattle Robotics Society	Washington
4	8.95	Kokopeli	Shawn Taylor Randy Clark Donald Nelson	New Mexico Tech	New Mexico

Table 2: Senior Division — Top Four robots out of 53 qualified (28 non-quals.).

plugged into the top side. I was well-pleased with how Breadbot turned out, and I have received many compliments by E-Mail and in person wherever I've demonstrated Breadbot.

The design proved to be very flexible, too, as evidenced by the ease with which I swapped out the BASIC Stamp 1 for a more powerful BS2, then a BS2 clone on a SIMMStick, and finally various SIMMStick PIC16F84 brains.

I still have more projects in mind for Breadbot, and a couple projects still to be completed, but I have been feeling the need to do something different for some months. As I was casting around for a new robot to build, I considered what types of robots are popular among amateurs and, by far, the most popular, successful robots around are competition robots. But which competition should I design for?

There are a bewildering variety of autonomous robot competitions out there, but they all fall into just a few broad categories: elementary competitions involving various aspects of robotics such as line following, maze solving, and dead reckoning; the robot sports ranging from Robocup soccer to robot sumo wrestlers to robot "blood sports" embodied in the utter destruction and mayhem of competitions such as Robot Wars; simulated robotics tasks such as firefighting, collecting "X" (where "X" can be tennis balls, soda cans, hockey pucks, etc.), and office navigation.

Robot Bloodsport?

I'm philosophically opposed to most robot bloodsports, not because I don't like the spectacle, but because I can't imagine spending so much time and money on a machine designed to be battered to pieces. I'm also a little weary of the elementary competitions. These are usually designed to exercise just one basic robot operational mode or sensing system.

As such, they are valuable for beginners because the problems the robot has to solve are stripped down to bare essentials. They can even be a bit of fun. The trouble is that the problems are so stripped down that it's hard to imagine the robots that come out of these competitions doing anything useful in the real world.

At the other extreme of complexity, are the simulated task competitions. These are often geared toward university and industrial research teams, and they usually put a premium on fast machine vision systems beyond the means of most amateurs. While these competitions, too, have their place, I want to design a robot with broader appeal, one that doesn't require expensive machine vision and massive parallel computing to be competitive.

Somewhere in the middle are sport competitions such as robot sumo wrestling and robot firefighting. I like the Japanese-style robot sumo events because they are fun to watch, and because the sport has depth. By depth I mean a beginner can do reasonably well with a simple, rugged robot, yet there is lots of room for advanced techniques. The same is true of robot firefighting, with the added bonus that you can actually imagine robot firefighters doing useful work in the near future.

So, I've narrowed the project down to designing a sumo or a firefighting robot. For Japanese-style sumo, robots are limited to a 20-cm-square footprint before starting, though the robot may change its geometry (e.g., deploy a pushbar) after the start of the match. There are no height restrictions, but the weight limit is 3 Kg (about 6.6 lbs.).

International Robot Groups

Region: Queensland, Australia
Group Name: Australian Computer Society, Robotics SIG
Contact: Tracy Lightfoot, (pres)
Aaron Dwyer, (sec'ry)
Email: T.Lightfoot@mailbox.gu.edu.au
aarond@nulec.com.au
URL: members.xoom.com/_XOOM/robot_sig/index.html#top
Meetings: 1st Tuesday of month, at 7:30 PM
Griffith University, Nathan Campus
Technology Building, Room 0.15
Address: Workcover Building, Adelaide St
Telephone: (07) 3220 0666

Region: Edmonton, Alberta Canada
Group Name: Edmonton Area Robotics Society
Contact: Pat Hogan, Conrad Braun
Email: hoganpj@oanet.com, cbraun@v-wave.com
URL: www.ualberta.ca/~nadine/ears.html
Meetings: 7:30-9:30 PM on 1st Wednesday of month
(except Jul & Aug)
Edmonton Space and Science Centre
Address:
Telephone: (403) 464-6751, (403) 481-3023

Region: Winnipeg, Manitoba Canada
Group Name: Winnipeg Area Robotics Society
Contact: Shaun Lee-Paget
Email: bev478@icenter.net
URL: www.winnipegrobotics.com
Meetings: Meetings 2nd Thursday at 7:00 PM
Address: U of M St. John's College room 118
92 Dysart Road
Telephone:

Region: Toronto, Ontario Canada
Group Name: Art & Robotics Group
Contact: Jeff Mann
Email: jefman@utcc.utoronto.ca
URL: www.interaccess.org/arg/
Meetings: Weekly meetings on Tuesday nights
Address:
Telephone:

Region: Waterloo, Ontario Canada
Group Name: Canada IEEE Student Branch
Contact: Ed Spike
Email: spike@eestaff.watstar.uwaterloo.ca
URL:
Meetings:
Address:
Telephone:

Region: France
Group Name: EFREI Robotique
Contact:
Email: robot@efrei.fr
URL: assos.efrei.fr/robot/
Meetings:
Address:
Telephone:

Region: (Internet)
Group Name: The Robotics Club of Yahoo (TRCY)
Contact: Justin Ratliff, president
Email: Weyoun7@aol.com
URL: clubs.yahoo.com/clubs/theroboticsclub
members.tripod.com/RoBoJRR
Meetings: weekly chat session every Wednesday
around 9 PM EST and ending around 11:30 PM
Address:
Telephone:

Region: Netherlands
Group Name: HCC Robotica gg
Contact: Ing. J.W. (Hans) Ligthelm
Email: j.w.ligthelm@kader.hobby.nl
URL: members.tripod.com/~hccrobotica/
Meetings:
Address:
Telephone:

Region: Edinburgh, Scotland UK
Group Name: University of Edinburgh Mobile Robots Group
Contact:
Email:
URL: www.dai.ed.ac.uk/groups/mrg/MRG.html
Meetings:
Address:
Telephone:

There are two divisions in this sumo style: radio control and autonomous.

For robot firefighting, the robot must fit within a 12.25-inch cube, and, unlike robot sumo, there are no weight limitations, and the firefighter must never extend beyond the 12.25-inch dimension in any direction during operation. The only exception to the latter rule is the use of an external power and/or control tether. My understanding of the rules also suggests that, although direct human control via radio is forbidden, radio data links would be allowable as long as the link served only as a wireless tether to a remote desktop computer. The key is that the robot must be autonomous.

But which robot to build? For a while, I considered doing a sumo robot. I consulted with Bill Harrison (www.sinerobotics.com), an expert on Japanese-style robot sumo.

Bill is a member of the Seattle Robotics Society and has been the driving force behind the Northwest Robot Sumo Tournament for many years. Bill regularly attends sumo competitions in North America and has even been to Japan for the All Japan Robot Sumo Tournament in Tokyo. He's burnt out more MOSFETs and stripped more gears than most people, so I figured he would be an excellent resource, perhaps even a team member.

The problem is for many years I have been wanting to build a firefighting robot, too. So, which was it to be, sumo or firefighter? I had a small flash of inspiration: Why not build a robot that could be configured for either competition? It seemed a little crazy at first blush.

Two Robots in One

Sumos tend to be squat, fast little armored wedges only a few inches tall that run on wall-less circular dohyos, while firefighters run in a maze-like model house and have to be tall enough to position their fire extinguisher (typically a fan) at candle height, between six and eight inches off the floor.

Sumo 'bots also tend to have very low ground clearance since they operate on dohyos, which have a very smooth rubberized running surface; firefighters, on the other hand, run on painted plywood and, in some operating modes, must contend with fiberglass "speedbump" ramps.

A beefy sumo 'bot would likely push such a ramp out of its way rather than actually go over it. A firefighter is penalized for ever touching a wall or (worse) the candle, but the whole raison d'être of sumo 'bot is to slam into its opponent, repeatedly.

Still, the idea wouldn't leave me. Sumos must be able to detect the edge of the dohyo which is marked by a white stripe; likewise, firefighters must recognize white stripes on a dark background because entrances to individual rooms in the model house maze are marked by such stripes. Sumo 'bot competition places a premium on speed and agility, and, though most firefighters are slower than sumo 'bots, speed and agility certainly don't hurt.

If a robot fit within the 20-cm footprint to qualify for sumo, it would also qualify for firefighting (as long as it wasn't taller than 12.25 inches). The main question left in my mind was whether a robot capable of competing in both sumo and firefighting could be anywhere near competitive in either.

A Robot of All Trades

When I mentioned the idea to Bill, he didn't laugh. In fact, he said he'd been considering the same idea himself. Well, maybe we could form a team.

For my part, I'm visualizing a square aluminum chassis a bit smaller than the 20 cm allowable footprint in sumo, maybe 18 cm square to leave room on all sides for customized scoops, pushbars, bumper plates, etc. I also see the box as

If you have suggestions, questions, or comments about amateur robotics topics, or if you want to come to High GEAR, you can now reach me at:

Robert Nansel
Box 228
Ambridge, PA 15003

The E-Mail address is the same:
E-Mail: bnansel@nauticom.net

being made from four identical sides with simple butt joints to reduce machining costs. The sides would be designed with several uncommitted mounting holes for attaching custom gear plus cutouts/lightening holes through which scoop actuators, linkages, wiring, or other hardware could pass.

My philosophy would be to make the chassis and drive train strong but considerably lighter than 3Kg so that the builder could add lead weights as needed to get the 'bot up to fighting weight; it's much easier to add ballast than to shave weight from a too-heavy robot.

I'm not aiming to make one robot that can instantly convert from sumo to firefighter (and back) so much as to make one chassis that both types of robot builders could use — and modify — for the two competitions. It's certainly possible to design a robot that transforms itself from a firefighter to a sumo, but I know if I designed such a convertible creature it would come out suboptimum for both types of competition.

I'm going more for the Meccano/Erector set approach — something general-purpose enough to build many different types of robots, but with enough built-in features to make building a few specific robots easier.

Mechanical Requirements

The main difference in mechanical requirements between the two competitions, as I see it, is that the firefighters don't have a guaranteed flat running surface (i.e., the speed-bump ramps mentioned above), so my thinking is to optimize the sumo suspension for running on a dohyo and the firefighter's for the ramps. The sumo's suspension would be pretty stiff and it would have little ground clearance; the fire-fighter needs something with more clearance and springiness to cope with the ~1/4-inch lip that some of the ramps have.

In firefighting, ramps are optional, but they get you better scores if your robot deals well with them. However, a straight sumo approach might work okay for competing in the firefighting contest without ramps, since the running surface is just painted plywood. You still need enough clearance to cope with the seam between the plywood sheets, and that can be as much as 1/8" (something that throws off many competitors in Hartford).

You can touch the walls — it just costs you. I think it's better to be able to recover from touching the wall. Sure, design the firefighter's sensors and software so that it should never have to touch a wall, but should be able to recover gracefully from bumping into a wall and still finish the contest.

On the sumo side, Bill advises me to be sure that the batteries are easy to swap out for Robot Sumo. At serious competitions, you change the batteries after every three minutes of use (so to become a champion, you need lots of battery packs).

High GEAR

That's all the space I have for this month, but before I go, I want to give a couple plugs. First, on the last weekend of July this summer I will be attending High GEAR (Great Escape And Retreat) in Washington State. As Karl Lunt, my predecessor in this column, mentioned in several of his columns, GEAR is the only event where folks go to think up great new ideas in amateur robotics specifically while camping.

For a few years, the SRS stopped doing GEAR because the Washington State parks changed over to a reservations-only system, and by the time people would start thinking about doing GEAR, our fave campsites would have all been taken. I, for one, have longed to revive the old robots-&-camping-in-the-woods retreat. The last GEAR I was able to attend was Fourth GEAR back in '94(!), so it's been far too long since I've gotten to hang with other gearheads and talk robots on the beach and on the Hobbit Trail.

Toward that end, I've reserved three campsites at South Whidbey Island State Park for two nights on July 28 and 29, Friday and Saturday. If your vacation plans will put you in the Pacific Northwest at the end of July, drop me a line ASAP so I can let you know if we still have room. See the sidebar for details. **NV**

Here are some useful links:

Robot firefighting:
www.trincoll.edu/events/robot

Robot sumo:
www.sinerobotics.com/sumo

Great new robotics site:
www.arsrobotica.com

A good place to buy robot parts:
www.acroname.com

A place to find books:
www.robotbooks.com

LETTERS ...

I just read your April article in *Nuts & Volts*. Are you attempting to compile a list of robot organizations and clubs? I think you also indicated if anyone was looking for a club in their area. I am a lone robot experimentor in Boise, ID that I know of. If you have had any respondents in Boise, I would love to make contact with them somehow. (P.S., I like your article! and thanks again.)

Bryan DeWeese
5185 Morris Hill Rd., #163
Boise, ID 83706
(208) 378-8588
gwyador@hotmail.com

I have been interested in your robot column for some time and have been gathering parts for a breadbot. I have been going backwards through your articles and have been unable to find the wheel information. I am in need of the source of wheels and or did you make them from something. I enjoy fabrication so either is fine with me. I am ready for encoders, etc. Also add my name to the robotics list without a club.

Dale Feldhausen, Manhattan, KS
Home: wynger@flinthills.com
Work: def@lc.mccall.com

I sent you a message when you were soliciting for people interested in robotics clubs. Alas, there were none in my area. After much thought, I decided I am willing to organize a club. I live in Milwaukee, WI and would be interested in starting a club here. I would appreciate if you could send a list of people in Wisconsin that are interested in robotics. If you would rather, please feel free to send my E-Mail address out to those in my area. Thank you for taking the time to help organize robotics enthusiasts.

Tom Gralewicz, Milwaukee, WI
mot@ieee.org

Congrats on your new workshop. My wife and I just bought a house and I have to install a complete shop (including wood, stone, and metal working facilities). My wife has some goofy idea that a garage should contain cars and lawn stuff instead of tools and workbenches. Yes, she is a little weird. Any way, please put my info on your list of robot people for clubs and conversations.

I am relatively new to this field, but would be really happy to talk to people in my area about clubs or general robot info. I have been starting with stamps and beam 'bots .

(P.S. Your advice about that *Mobile Robots* book was great and now I have platforms running around the house making my wife crazy. Very cool stuff.)

Robert Malinowski
Doylestown, PA
Malstudios@tradenet.net

I really enjoy Robotics and would like to contact others in the Chicagoland area who are interested in the same. I am interested in the 'Bot wars people seem to be doing out on the west coast. I would love to get a team together to enter this kind of contest.

Michael Hoag, Chicago, IL
Days: (773) 463-6565
Eves: (773) 836-7119
mhjames@wwa.com

It was a pleasure meeting you at Trinity last Saturday. Do you have a list serve for local robotics clubs? If so, could I be added to the list?

Rex M. Marling
8625 S. Franklin Rd.
Indianapolis, IN 46259
microrex@yahoo.com

I have been following your column in *Nuts & Volts* and think you may be able to help. Is there an Amateur Robotics group local to the Central New Jersey area? My class' efforts are briefly described at http://dpein.home.netcom.com. We are hosting an open house at our school on June 1st to increase community awareness and to develop support for our participation in a robotics competition next year (preferably one not sponsored by Disney).

David Peins
dpein@ix.netcom.com

I am a Technology Teacher at Westhill HS in Syracuse, NY. I am currently working on activities for kids in my class using the BASIC Stamp. I would like kids to be able to use the Stamp for Robotics, as well as the controlling device for some teaching equipment called Fishertechniks.

Fishertechniks are similar to Legos, but the parts look more like actual manufacturing cell parts. Instead of aluminum extruded structural pieces, the Fishertechniks are plastic.

I am interested in a Robotics club for myself and maybe some contacts for my kids! I am still learning the driver circuits, buffers, forward and reversing circuits, sensor circuits. I want to have the kids learn all this too once I have learned them. I think the club would be a great resource for me. I subscribe to *Robotics* and *Nuts & Volts*. I know of the SME and FIRST Robotics contests. I need to be a little more knowledgeable before I get there.

At Westhill, I teach Digital Electronics, Solid Modeling (CAD), Computer Integrated Manufacturing, and some of the traditional shop classes. We also have a Sci Tech Club where we are currently building RC sumo cars. Then we will be entering an RC robotics contest. My job is awesome!!!!!

Let me know about any clubs (also for kids) in my area and thanks for all the great articles you have done so far!!!!

John Pierce
Technology Teacher
Westhill High School
4501 Onondaga Blvd.
Syracuse, NY 13219
JPIERCEMEL@cs.com

I'm from Holland. I have copy from *Nuts & Volts*. I'm new in the robotics world and not familiar with programming. I'm more a hardware person but I think that Stamp tech can help me with both. I'm looking for people that are in the robotics world. And can help me on my way. I have a copy of *The Robotics Experimenters Bonanza*. But that doesn't deal with programming. Can you help me with titles of books and do you know more people in robotics? If you can help me, I would be very grateful.

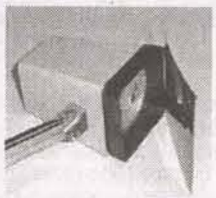
A robo freak.

Tom van Roon, Holland
tomvan_roon@hotmail.com

This E-Mail is obviously in response to you requesting in *Nuts & Volts* for contact info of all of us without access to a robotics club.

Timothy Weghorst
2810 Manor Rd.
Coatesville, PA 19320
(610) 380-0748
robotics@voicenet.com

Continued from page 42



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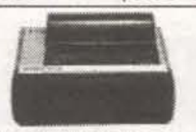

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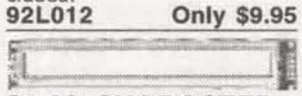

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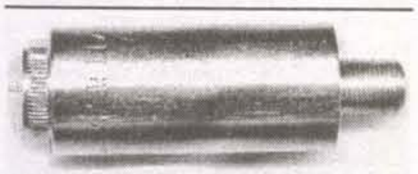

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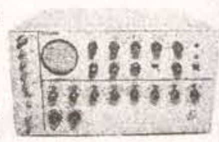

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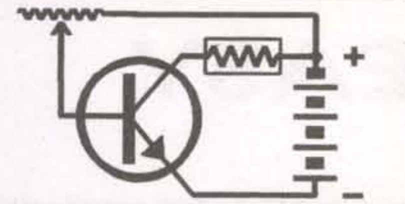

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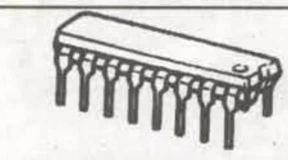

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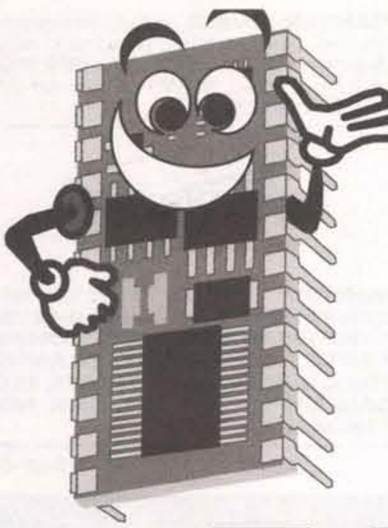

by Jon Williams

Stamp Applications

MENUS MADE EASY

Putting the Spotlight on BASIC Stamp Projects, Hints, and Tips

When it comes right down to it, I'm a very lucky guy. Really. I have a wonderful family, terrific friends, I live in one of the best cities in the world, and I get to work with some really bright people. Like my friend, Will, for example. Now this guy is definitely one of the sharpest knives in the drawer. I love working with him; he inspires me on a daily basis.

Will and I work for a company that manufactures water-pumping stations for golf courses. Our big stations use off-the-shelf PLCs for control. The price of the PLC is easy to justify due to the sophistication of control required and the volume of stations we sell. But now that we're moving into the simpler municipal water market, the PLC is just a bit expensive.

That's no longer a problem for us — thanks to Will. He spent the last year designing a custom pumping station controller from the ground up. It's a real beauty and has been a big hit, inside the company and out. A very big reason, I believe, is the elegance and simplicity of its user interface.

I'll admit that I'm biased here. When it comes to user interfaces, I have been justifiably called anal-retentive. It's a fair criticism — I'm a nut when it comes to UI design. I'm a very big believer in UI standards, even if they're only loosely defined. Nothing throws me off about a piece of software more than a poorly designed or non-standard interface.

When it comes to the PC — especially in our "Windowed" world — designing to standard is pretty easy since there are a lot of good examples. There's even a set of written guidelines, called the CUA. But what do we do when it comes to industrial controllers?

I'm not suggesting that all industrial controls should have a common interface. What I am suggesting is that a simple and intuitive interface can be developed and applied to our Stamp projects. That's the goal here: apply Will's great UI design to the BASIC Stamp, creating a platform from which we can develop any number of distinct control projects. And just as we're able to navigate any properly designed Windows® program, we should be able to easily navigate any of our control projects that follow the standard we develop here.

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Keeping It Simple

Yep, back to the KISS principle — keep it simple, silly. The user interface on Will's controller uses six buttons and a two-line LCD. With this simple interface, he created a multi-level menu system that is intuitive and easy to navigate (our design goal). So how do we duplicate that on a Stamp?

Using a conventional approach, connecting to six buttons would take six lines and connecting to the LCD (assuming four-bit mode) would take another six; 12 total lines. Yikes — that doesn't leave much left to connect to the outside world. There's got to be another way.

And there is. Using SHIFTIN and SHIFTOUT, we can add a couple of 50¢ shift registers to our project and reduce the I/O lines required for the interface to five. That's much better. The schematics for our demo project are shown in Figures 1 (LCD) and 2 (buttons).

Since I've covered the use of the 74HC595 with LCDs in past

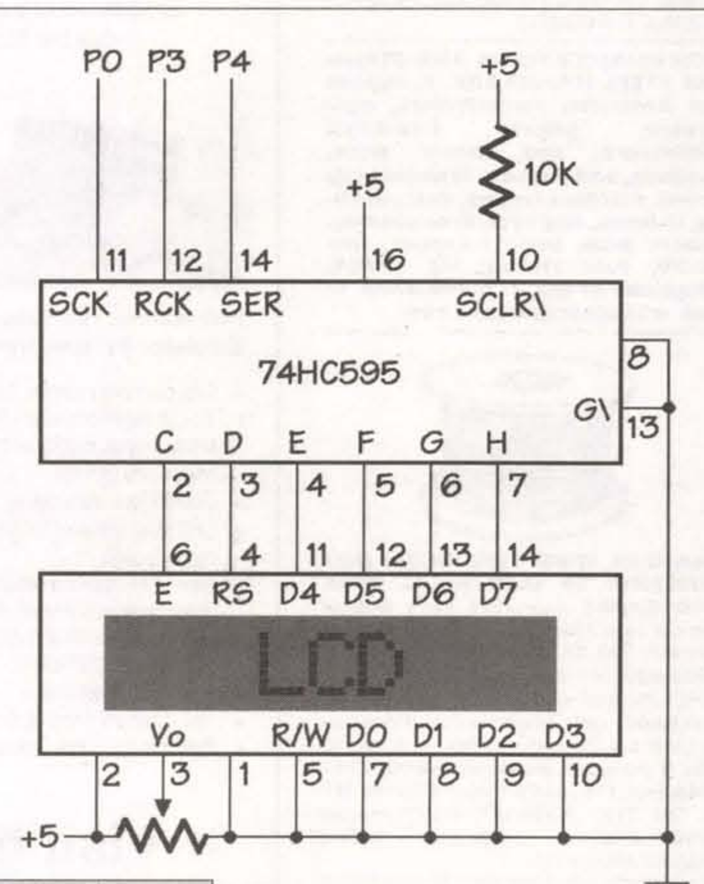

Figure 1

articles, I'm not going to deal with it here except to say that with a little planning, you can easily cascade the additional 75HC595s to create more outputs. You'll need to connect the serial output (pin 9) of one 74HC595 to the serial input (pin 14) of the next. The Clock (pin 11) and Latch (pin 12) lines need to be tied together.

We'll use the 74HC595's compliment, the 74CH165 parallel-in/serial-out shift register to read our buttons. Since we're only using six inputs, the other two could be used as configuration switches, additional buttons, anything the project requires. And like the 74HC595, the 74HC165 can be cascaded if we ever need additional inputs.

Keyboard Debouncing

Debouncing one input with a Stamp is pretty easy with the BUTTON command, but what happens when we want to debounce six inputs and do it simultaneously? As it turns out, the solution is not particularly difficult and takes very little code. Take a look at Listing 1, down in the subroutines section. Look for the routine called GetKey.

GetKey returns inputs that have been held stable for about 25 milliseconds. That should be enough time to validate the button press and we can easily adjust the debounce timing, if required. Here's how GetKey works: On entry to the routine, we assume that all the buttons are pressed (this may seem odd, but will make sense in just a second). Then we scan the inputs and logically AND them with the current value. If a button has released due to contact-bounce, it will have a bit-value of zero. Zero ANDed with one is zero and will remain at zero through the remainder of the routine. Only a button that stays down (bit value of 1) during the entire loop will return as a valid input. This technique can be used with nibbles, bytes, or words — up to 16 inputs can be simultaneously debounced.

Sharp readers (that's all of you) are probably asking, "Wait, Jon, how can the inputs return a value of one when pressed if we've connected the buttons between the shift register inputs and ground?" Good catch. Look again at the schematic in Figure 2. We're using the inverted serial output from the 74HC165 to restore the positive logic for us. If we ever want to modify GetKey to deal with direct inputs, we would change the test line to look like this:

```
key = key & ~tempB
```

The tilde (~) in front of tempB inverts the bits for us.

In this program, GetKey uses the SHIFTIN function to retrieve the buttons from the 75HC165. Before we can use SHIFTIN, however, we have to pulse the Shift/Load line from high-to-low, then back to high. This action "grabs" the buttons and holds them while we do the shifting. If any of the inputs change while we're shifting the data, we won't see it until the next scan.

Menu, Please

Last month, we talked about project planning and that certainly applies here. In addition to any control functionality, we need to define our menu structure so that it makes sense to the user and is easy to navigate.

The goal of our demo program is to allow the user to set the time and day. To that end, we've set up three operational modes: display current time and day (mode 0), set time (mode 1), and set day (mode 2). Since setting the time is easier to do by individually setting the hours and the minutes, the set time mode has two levels. Note that zero is always used to indicate the topmost element in either structure. Mode 0, then, is our "normal" operational display. A level of zero indicates a menu display only. Once we get into actual value editing, we indicate the element to change with a non-zero level value.

Both mode and level are defined as nibbles, allow up to 15 menu items (beyond the normal display), and 15 levels within each menu. Our program is much simpler than that. Here's how the menu for our demo program is mapped:

```
mode       level

0 : display time and day

1 : SET TIME
    1 : set hours
    2 : set minutes

2 : SET DAY
    1 : set day of week
```

Navigation Rules

With our menu structure in place, we need to define the rules by which we'll navigate through it. As we stated earlier, there are six buttons. Here's how they'll work:

```
' Nuts & Volts "Stamp Applications" - June 2000
' Listing 1

'==========================================================================
' Program... STAMPUI.BS2
' Purpose... Stamp User-Interface for general control applications
' Author.... Jon Williams
' E-mail.... jonwms@aol.com
' ==========================================================================


' —-[ Program Description ]———————————————
'
' This program demonstrates a multi-level menu system using a keypad input
' and LCD output.  Stamp pins are conserved by using shift registers for
' the keys and LCD.


' —-[ Revision History ]——————————————
'


' —-[ I/O Definitions ]——————————————
'
Clock    CON      0                          ' shared clock line
SL_165   CON      1                          ' shift/load of 74HC165
DI_165   CON      2                          ' serial data from
74HC165
L_595    CON      3                          ' 74HC595 output latch
DO_595   CON      4                          ' serial data to 74HC595


' —-[ Constants ]————————————————
'
ClrLCD   CON      $01                        ' clear the LCD
CrsrHm   CON      $02                        ' move cursor home
CrsrLf   CON      $10                        ' move cursor left
CrsrRt   CON      $14                        ' move cursor right
DispLf   CON      $18                        ' shift chars left
DispRt   CON      $1C                        ' shift chars right

Crsr1    CON      %00001110                  ' underline cursor on
Crsr0    CON      %00001100                  ' underline cursor off

DDRam    CON      $80                        ' Display Data RAM control
CGRam    CON      $40                        ' Char Gen RAM control

Line1    CON      $00                        ' line 1, column 0
Line2    CON      $40
Line3    CON      $14
Line4    CON      $54

Key_Up   CON      %000001                    ' input keys
Key_Dn   CON      %000010
Key_Lf   CON      %000100
Key_Rt   CON      %001000
Key_OK   CON      %010000
Key_Set  CON      %100000

RunMode  CON      0                          ' menu displays
MNU_Tm   CON      1
MNU_Day  CON      2

SET_Hr   CON      1                          ' setting hours
SET_Min  CON      2                          ' setting minutes
SET_Day  CON      1                          ' setting day

D_Sun    CON      0                          ' days of week
D_Mon    CON      1
D_Tue    CON      2
```

Set	Enter menus or editing within a menu
OK	Move up one level
Up	Previous menu item or increment value
Down	Next menu item or decrement value
Right	Move to next field
Left	Move to previous field

As you can see, things get started by pressing the "Set" button. This will take us from our normal ("run") display into the menus. We will use "Up" and "Down" to select a specific menu item. With the desired menu item displayed, we'll press "Set" again. This will put us into edit mode (level one for the selected menu). We can change a value in edit mode by using "Up" and "Down." If there are multiple fields to edit for the selected menu item, we can move through the fields by pressing "Left" and "Right." Pressing "OK" in edit mode takes us back up to the menu so that we can select another. Finally, pressing "OK" while in the menu takes us back to the "run" display.

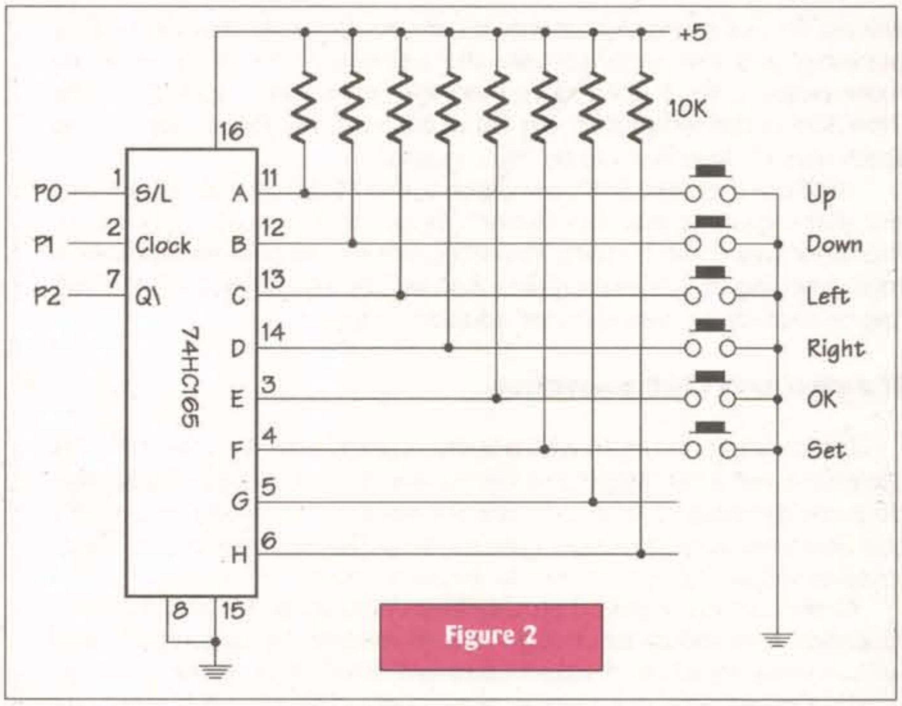

Figure 2

Putting It All Together

Okay, we know what we want to do and how our program should behave, so let's put it all together. We'll start, as always, by defining CONstants that will help make the code self-documenting. We use quite a few in this program and they really do help.

Operationally, we kick off the program by initializing the LCD and program variables. Since we only have eight bits available from the 75HC595, we'll use the four-bit interface to the LCD as this mode requires only six lines. This LCD is also initialized to use multiple lines. The same initialization sequence will work with two- or four-line LCDs.

```
D_Wed     CON     3
D_Thu     CON     4
D_Fri     CON     5
D_Sat     CON     6

Yes       CON     1
No        CON     0


' ----[ Variables ]------------------------------
'
key       VAR     Byte                  ' key input
char      VAR     Byte                  ' character out to LCD
temp      VAR     Byte                  ' work variable for LCD
lcd_E     VAR     temp.Bit2             ' LCD Enable pin
lcd_RS    VAR     temp.Bit3             ' Reg Select (1 = char)
addr      VAR     Byte                  ' EE address for LCDprint
base      VAR     Byte                  ' base for display

hrs       VAR     Byte                  ' hours
mins      VAR     Byte                  ' minutes
day       VAR     Nib                   ' day of week, 0 to 6

state     VAR     Byte                  ' program state
mode      VAR     state.HighNib         ' menu mode
level     VAR     state.LowNib          ' edit level

tempW     VAR     Word                  ' general purpose word
temp1     VAR     tempW.HighByte
temp2     VAR     tempW.LowByte
tempB     VAR     Byte                  ' general purpose byte
loop      VAR     Byte                  ' loop counter

flags     VAR     Nib
updtLCD   VAR     flags.Bit0            ' update LCD flag


' ----[ EEPROM Data ]----------------------------
'
Digits    DATA    "0123456789ABCDEF"    ' digits for LCDnum2 sub

Days      DATA    "SUN", 0              ' day strings
          DATA    "MON", 0
          DATA    "TUE", 0
          DATA    "WED", 0
          DATA    "THU", 0
          DATA    "FRI", 0
          DATA    "SAT", 0

LCD_ST    DATA    "SET TIME", 0         ' menu strings
LCD_SD    DATA    "SET DAY", 0

' ----[ Initialization ]-------------------------
'
' Initialize the LCD (Hitachi HD44780 controller)
'
LCDinit:
          PAUSE 500                     ' let the LCD settle
          char = %0011                  ' 8-bit mode
          GOSUB LCDcmd
          PAUSE 5
          GOSUB LCDcmd
          GOSUB LCDcmd
          char = %0010                  ' put in 4-bit mode
          GOSUB LCDcmd
          char = %00101000              ' 2-line mode
          GOSUB LCDcmd
          char = %00001100              ' disp on, crsr off
          GOSUB LCDcmd
          char = %00000110              ' inc crsr, no disp shift
          GOSUB LCDcmd
          char = ClrLCD
          GOSUB LCDcmd


Initialize:
          updtLCD = Yes                 ' refresh the LCD
          state = RunMode               ' top menu

          hrs = 12
          mins = 34
          day = D_Sun


' ----[ Main ]-----------------------------
'
Main:
          GOSUB GetKey
          BRANCH mode, [Mode_Run, Mode_Time, Mode_Day]
          GOTO LoopPad100

' ========================
'  Run Display (top level)
' ========================

Mode_Run:
          IF updtLCD = No THEN Mode_Run2   ' no update, check key
          char = Crsr0                  ' clear cursor from edit
          GOSUB LCDcmd
          char = ClrLCD                 ' clear the LCD
          GOSUB LCDcmd
          GOSUB PrintTime               ' print the time
          char = DDRam + Line1 + 6      ' move to position 6
          GOSUB LCDcmd
          GOSUB PrintDay                ' print the day
          updtLCD = No                  ' LCD updated

Mode_Run2:
          IF key <> Key_Set THEN LoopPad100   ' "Set" not pressed
          mode = MNU_Tm                 ' "Set" pressed, Time
menu
          level = 0                     ' menu level
          updtLCD = Yes                 ' update the LCD
          GOTO LoopPad250               ' allow key release
```

MENUS MADE EASY

Like our exercise timer last month, this program runs in a continuous loop. Each pass through the loop scans the buttons then BRANCHes to the handler for the current mode and level. It is within the menus or edit code that we will process any button inputs. Let's follow the program from startup though setting the time. Along the way, we'll try every possible button press so that the program is understood.

The program loop starts by scanning the buttons and placing the result in a variable named key. With level set to zero, the program BRANCHes to the line labeled Run_Mode. Since the flag variable updtLCD was initialized to Yes (1), the code drops through the IF...THEN and prints the time and day on line one of the LCD. Keep in mind that this is just a demonstration program and that the time and date are not automatically updated.

You might wonder why we go through the trouble to keep track of when the LCD needs to be updated. The reason is two-fold: we can save a little time by not writing to the LCD when there are no changes to be displayed, and we keep the display "clean" as constant updates to the LCD can cause an annoying flash.

We've simplified the program by printing the time and day from subroutines (PrintTime and PrintDay). These subroutines allow us to print at the current cursor position of the LCD. PrintTime calls a neat little routine called LCDdec2. This routine is similar to the DEC2 modifier for DEBUG or SEROUT. Look closely at the code. Just above is an entry point called LCDhex2. This works like the HEX2 modifier.

Both LCDdec2 and LCDhex2 set the base value for the working section of code, LCDnum2. This bit of code will print a two-digit number at the current cursor position of the LCD. Notice that we don't actually calculate the character to print (as we typically do), but instead, we calculate the character's position in an EEPROM table. Then we read it from the EEPROM and print it. This is how the same code can be used to print decimal or hex numbers. In fact, by setting the variable base to eight, we could print a two-digit octal number as well.

```
' ==============
'  Time Display
' ==============

Mode_Time:
        ' branch to current mode level
        BRANCH level, [Time_Menu, Time_Hours, Time_Mins]
        GOTO LoopPad100

Time_Menu:                                        ' display "SET TIME"
        IF updtLCD = No THEN Time_Menu2           ' update on if required
        char = Crsr0
        GOSUB LCDcmd
        char = ClrLCD
        GOSUB LCDcmd
        addr = LCD_ST
        GOSUB LCDprint
        updtLCD = No

Time_Menu2:
        IF key <> Key_OK THEN Time_Menu2a         ' check "OK"
        state = RunMode                           ' - pressed; up to top
        updtLCD = Yes
        GOTO LoopPad100

Time_Menu2a:
        IF key <> Key_Set THEN Time_Menu2b        ' check "Set"
        level = SET_Hr                            ' - pressed; set hours
        updtLCD = Yes
        GOTO LoopPad250

Time_Menu2b:
        IF key <> Key_Dn THEN LoopPad100          ' check "Down"
        mode = MNU_Day                            '  - move to day menu
        updtLCD = Yes
        GOTO LoopPad250

Time_Hours:                                       ' display hours with cur-
sor
        IF updtLCD = No THEN Time_Hours1          ' - if refresh required
        char = Crsr0                              ' no cursor during refresh
        GOSUB LCDcmd
        char = DDRam + Line2                      ' time on Line 2
        GOSUB LCDcmd
        GOSUB PrintTime
        char = DDRam + Line2 + 1                  ' cursor under hours
        GOSUB LCDcmd
        char = Crsr1
        GOSUB LCDcmd
        updtLCD = No

Time_Hours1:
        IF key <> Key_OK THEN Time_Hours1a        ' check "OK"
        level = 0                                 ' - back to menu
        updtLCD = Yes
        GOTO LoopPad250

Time_Hours1a:
        IF key <> Key_Up THEN Time_Hours1b        ' check "Up"
        hrs = hrs + 1 // 24                       ' - increment with
rollover
        updtLCD = Yes
        GOTO LoopPad250

Time_Hours1b:
        IF key <> Key_Dn THEN Time_Hours1c        ' check "Down"
        hrs = hrs + 23 // 24                      ' - dec with rollunder
        updtLCD = Yes
        GOTO LoopPad250

Time_Hours1c:
        IF key <> Key_Rt THEN LoopPad100          ' check "Right"
        level = SET_Min                           ' - set minutes
        updtLCD = Yes
        GOTO LoopPad100

Time_Mins:                                        ' display mins with cursor
        IF updtLCD = No THEN Time_Mins1           ' - if refresh required
        char = Crsr0
        GOSUB LCDcmd
        char = DDRam + Line2
        GOSUB LCDcmd
        GOSUB PrintTime
        char = DDRam + Line2 + 4                  ' cursor under minutes
        GOSUB LCDcmd
        char = Crsr1
        GOSUB LCDcmd
        updtLCD = No
        GOTO LoopPad100

Time_Mins1:
        IF key <> Key_OK THEN Time_Mins1a         ' check "OK"
        level = 0                                 ' - back to menu
        updtLCD = Yes
        GOTO LoopPad100

Time_Mins1a:
        IF key <> Key_Up THEN Time_Mins1b         ' check "Up"
        mins = mins + 1 // 60                     ' - inc with rollover
        updtLCD = Yes
        GOTO LoopPad100

Time_Mins1b:
        IF key <> Key_Dn THEN Time_Mins1c         ' check "Down"
        mins = mins + 59 // 60                    ' - dec with rollunder
        updtLCD = Yes
        GOTO LoopPad100

Time_Mins1c:
        IF key <> Key_Lf THEN LoopPad100          ' check "Left"
        level = SET_Hr                            ' - set hours
        updtLCD = Yes
        GOTO LoopPad100


' =============
'  Day Display
' =============

Mode_Day:
        ' branch to current mode level
        BRANCH level, [Day_Menu, Day_Set]
        GOTO LoopPad100

Day_Menu:                                         ' display "SET DAY"
        IF updtLCD = No THEN Day_Menu2            ' - if refresh required
        char = Crsr0
        GOSUB LCDcmd
        char = ClrLCD
        GOSUB LCDcmd
        addr = LCD_SD
        GOSUB LCDprint
        updtLCD = No

Day_Menu2:
        IF key <> Key_OK THEN Day_Menu2a          ' check "OK"
        state = RunMode                           ' - back to top
        updtLCD = Yes
        GOTO LoopPad100

Day_Menu2a:
        IF key <> Key_Set THEN Day_Menu2b         ' check "Set"
```

PrintDay also takes advantage of data stored in the EEPROM, in this case, zero-terminated strings. By storing our strings in the EEPROM, we can easily make changes — even change the language of our displays should we ever decide to internationalize the project. The routine that puts the string on the LCD is called LCDprint. What we have to do is set the variable addr to the first character of the string to print. LCDprint will loop through the EEPROM from that point, printing the characters it reads until it encounters a zero. So we have to make sure that we end our strings with zero, otherwise we'll end up with a corrupted display.

Okay, the time and date is displayed and the program is waiting for an input. The only button that does anything from the top level is "Set," so let's press it. When we do, the mode variable is set to MNU_Tm (1) and level is cleared to zero. Since we're going to change to a new display, we tell the program by setting updtLCD to Yes. We exit the current action by jumping to LoopPad250. This label finishes the loop and gives us a 250-millisecond delay — enough time to release the button. In other cases, we'll use a 100-millisecond loop delay by jumping to LoopPad100.

On our next pass through the main loop, we will BRANCH to line labeled Mode_Time. As with Mode_Run, we will update the display and wait for a valid button. Again, we'll use the routine LCDprint to send a string ("SET TIME") to the display. Pressing "OK" at this level causes us to return to the top. This is achieved by setting the variable state to

```
        level = SET_Day                         ' - set day
        updtLCD = Yes
        GOTO LoopPad250

Day_Menu2b:
        IF key <> Key_Up THEN LoopPad100        ' check "Up"
        mode = MNU_Tm                           ' - back to time menu
        level = 0
        updtLCD = Yes
        GOTO LoopPad100

Day_Set:
        IF updtLCD = No THEN Day_Set1
        char = Crsr0
        GOSUB LCDcmd
        char = DDRam+ Line2
        GOSUB LCDcmd
        GOSUB PrintDay
        char = DDRam + Line2
        GOSUB LCDcmd
        char = Crsr1
        GOSUB LCDcmd
        updtLCD = No
        GOTO LoopPad100

Day_Set1:
        IF key <> Key_OK THEN Day_Set1a         ' check "OK"
        level = 0                               ' - back up to menu
        updtLCD = Yes
        GOTO LoopPad100

Day_Set1a:
        IF key <> Key_Up THEN Day_Set1b         ' check "Up"
        day = day + 1 // 7                      ' - inc with rollover
        updtLCD = Yes
        GOTO LoopPad250

Day_Set1b:
        IF key <> Key_Dn THEN LoopPad100        ' check "Down"
        day = day + 6 // 7                      ' - dec with rollunder
        updtLCD = Yes
        GOTO LoopPad250

' ==================
' End of Main Loop
' ==================


LoopPad250:                                     ' 250 ms pad
        PAUSE 150

LoopPad100:                                     ' 100 ms pad
        PAUSE 100
        GOTO Main


' ---[ Subroutines ]-----------------------------
'

' Send command to the LCD
'
LCDcmd:
        lcd_RS = 0                              ' command mode
        GOTO LCDout


' Write ASCII char to LCD
'
LCDputc:
        lcd_RS = 1                              ' character mode
        GOTO LCDout


' send char to LCD
'
LCDout:
        temp.HIGHNIB = char.HIGHNIB             ' get high nibble
        lcd_E = 1
        SHIFTOUT DO_595, Clock, MSBFIRST, [temp]
        PULSOUT L_595, 1
        lcd_E = 0                               ' drop Enable line low
        SHIFTOUT DO_595, Clock, MSBFIRST, [temp]
        PULSOUT L_595, 1
        temp.HIGHNIB = char.LOWNIB              ' get low nibble
        lcd_E = 1
        SHIFTOUT DO_595, Clock, MSBFIRST, [temp]
        PULSOUT L_595, 1
        lcd_E = 0
        SHIFTOUT DO_595, Clock, MSBFIRST, [temp]
        PULSOUT L_595, 1
        RETURN


' send EE string to LCD
' - string starts at addr and ends with zero
'
LCDprint:
        READ addr, char                         ' get character from EE
        IF char = 0 THEN LCDprintX              ' if 0, we're done
        GOSUB LCDputc                           ' write the character
        addr = addr + 1                         ' point to next character
        GOTO LCDprint
```

MENUS MADE EASY

RunMode. If you look carefully through the variable definitions, you'll see that our variable's mode and level are actually aliased elements of state. Setting state to zero (RunMode) clears mode and level at the same time.

Let's return to the "SET TIME" menu and then press "Set." This causes us to enter the editing mode by setting level to SET_Hr (1). On the next pass through the program loop, we will end up at the label called Time_Hours. This bit of code will put the current time on line two and place a visible cursor under the hours value.

In hours editing mode, more buttons are used. Pressing "OK" clears level to zero and returns us to the menu where we can make another selection. We can change the hours value by pressing either "Up" or "Down." Both routines keep the hours value within range by using the modulus (//) operator. I find this technique easier (less code) and more user-friendly for interfaces like we're designing. Pressing "Up" or "Down" necessitates a display change, so we'll set updtLCD to Yes.

With the hours set, we move to the minutes field by pressing the "Right" button. This causes level to be set to SET_Min (2), forcing the program to move to the minutes editing routines. As before, we indicate that we're editing by placing the cursor under the minutes value. Button processing is identical to setting the hours. Once we're satisfied, pressing "OK" twice will return us to our topmost display.

And we're done. The "run" display will now show the new time. Setting the day works the same, but only requires one edit level. In an operational program, we would use our new interface to update a real-time-clock.

Wrap Up

Another one of those sharp guys I know in Dallas is Roger Arrick, the owner of Arrick Robotics (check out Roger's Stamp-controlled ARobot at www.robotics.com). Roger's E-Mail tag line is, "It's Harder Than It Looks." That was the case with this menu system. Now, I don't want you to be put off by this, I'm just warning you to take your time with your menu design and program development, lest your project take off to la-la land. It is a bit of work and yet, I think you'll agree — and your customers will agree — that the result is well worth the effort. Happy Stamping. **NV**

Resources:

Jon Williams
3718 Valley View Lane, #3040
Irving, TX 75062
(972) 659-9090
jonwms@aol.com

Parallax
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Rocklin, CA 95756
(888) 512-1024
www.parallaxinc.com

Scott Edwards Electronics, Inc.
1939 S. Frontage Rd. Ste. F
Sierra Vista, AZ 85635
phone **520-459-4802**
fax **520-459-0623**
www.seetron.com
info@seetron.com

```
LCDprintX:
        RETURN


' print 2-digit number on LCD
'
LCDdec2:
        base = 10                               ' display number as deci-
mal
        GOTO LCDnum2

LCDhex2:
        base = 16                               ' display number as hex

LCDnum2:
        READ Digits + (tempB / base), char      ' high digit
        GOSUB LCDputc
        READ Digits + (tempB // base), char     ' low digit
        GOSUB LCDputc
        RETURN


GetKey:
        key = %00111111                         ' assume all pressed
        FOR loop = 1 TO 5                       ' test five times
          LOW SL_165                            ' load data from keys
          PAUSE 1
          HIGH SL_165                           ' allow data to shift in

          SHIFTIN DI_165, CLOCK, MSBPRE, [tempB\8]

          key = key & ~tempB                    ' test against new input
          PAUSE 5                               ' wait 5 ms between tests
        NEXT
        RETURN


PrintTime:
        tempB = hrs
        GOSUB LCDdec2
        char = ":"
        GOSUB LCDputc
        tempB = mins
        GOSUB LCDdec2
        RETURN


PrintDay:
        addr = Days + (day * 4)                 ' point to day string
        GOSUB LCDprint                          ' print it
        RETURN
```

See Page 4 for details!!

Old Scopes Don't Need to Die — A Repair Story

Many electronics bargains can be found today at swap meets, hamfests, and in Nuts & Volts ads. But what if they don't work? This is a case study involving the repair of a useful oscilloscope manufactured in the late 1950s. Along the way some basic troubleshooting is described, as well as details about taking scope screen photos. Although the story is true, the characters are fictional.

by Fred Blechman

I must admit that when Steve, my knows-enough-to-be-dangerous regular customer called to tell me about a problem he was having with his old RCA oscilloscope, I wasn't sure whether I was willing to work on such an old piece of equipment. He said the unit was working, but that when it got hot, the traces became distorted. This could be caused by any number of problems, especially since this unit was designed using vacuum tubes.

Steve admitted that he had tried changing tubes and had generally poked around inside the unit, but the problem remained. "Bob," he said, "I did notice that when I ran the scope without the metal case, the distortion was still there — but not as bad."

Several things made me willing to tackle the repair. For one thing, at least the oscilloscope was working and displayed patterns, so the power supply and cathode ray tube (CRT) were probably okay. A big plus was that Steve had the complete manual, including the schematic. Nothing ventured, nothing gained.

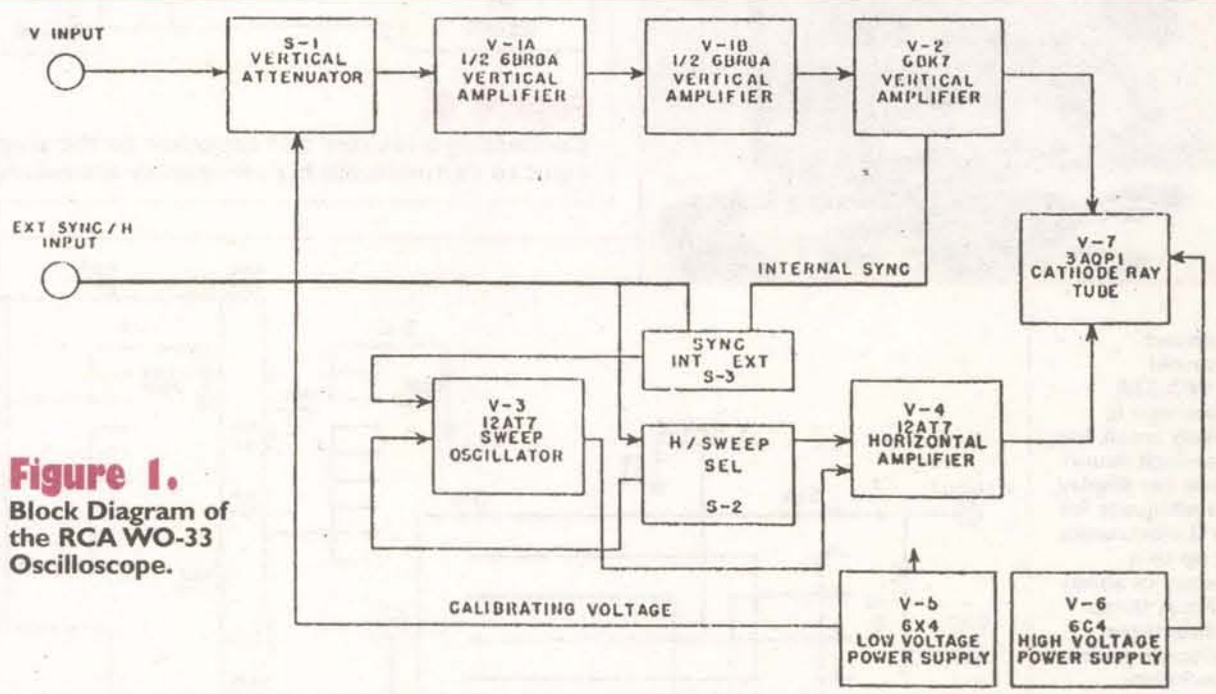


Figure 1.
Block Diagram of the RCA WO-33 Oscilloscope.

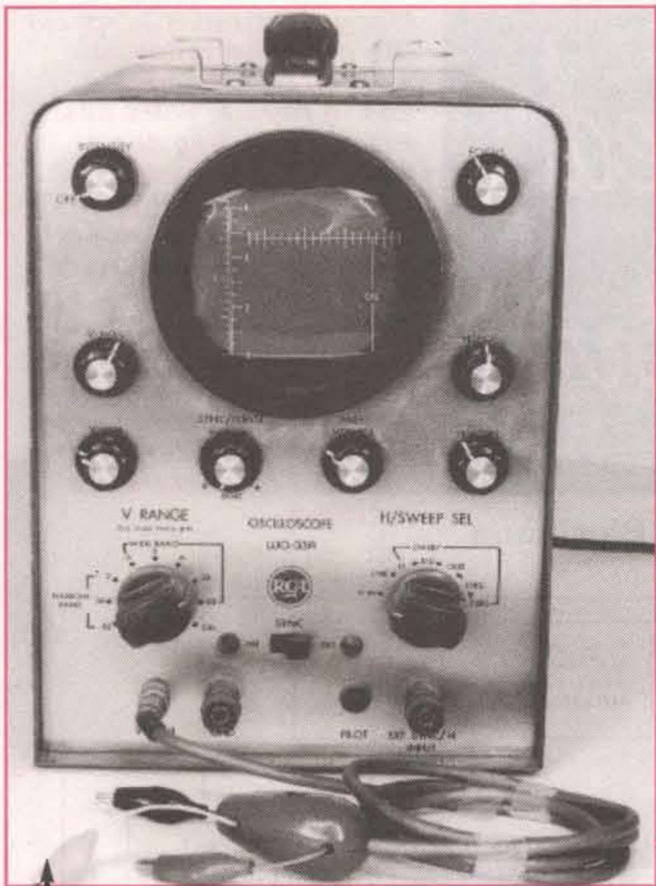
The RCA WO-33A Oscilloscope

Steve brought over his old RCA oscilloscope, and it was apparent at first glance that it was of the old-fashioned variety, with the cathode ray display at the top, and most of the controls below — a vertical design as compared to modern oscilloscopes with their horizontal layout.

It was also apparent that, although the scope had seen better days, it did not appear abused, and even included the original combination three-lead direct/low capacitance 10X probe. The 23-page Instruction Booklet was complete, including a parts list, two-page schematic diagram, and lots of illustrations, tables, and diagrams. It was also interesting to note the "PRICE ONE DOLLAR" printed in the upper right corner. A manual like this today would probably be more like $25.00!

The RCA WO-33A, which you might find these days at ham or electronics swap meets (which is where Steve bought his about 30 years ago for only $50.00!), or on an Internet auction site, uses a three-inch round CRT display. It was designed for "on location" and shop use in servicing color and black-and-white television receivers, hi-fi equipment, public address and sound reinforcing equipment, broadcast station and remote equipment, as well as communications and industrial electronic equipment of all sorts.

However, it was produced before digital circuits were common, and has a limited frequency response (to 5.5MHz). The least expensive modern



The almost 40-year-old RCA WO-33A Oscilloscope is relatively small, has a three-inch round cathode ray display, and is adequate for general electronics work up to a frequency of about 5.5MHz. A three-lead direct/low capacitance probe was included.

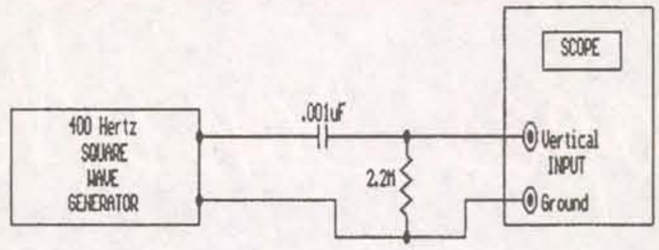


Figure 3.

Connecting a capacitor and resistor to the scope input to demonstrate low-frequency attenuation.

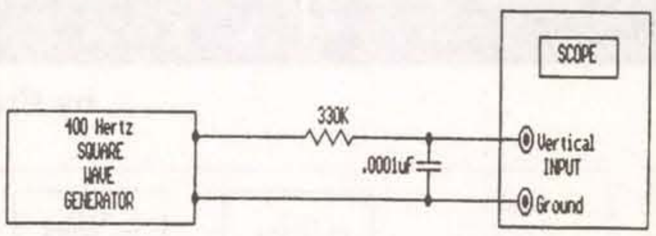


Figure 4.

Connecting a resistor and capacitor to the scope input to demonstrate high-frequency attenuation.

scopes go to 20MHz and better ones go to 100MHz and beyond.

Despite its small size and weight for a vacuum tube type scope (roughly 9-inches high, 6.5-inches wide, and 10.5-inches deep, with a weight of 14 pounds), the WO-33A has quite a few handy features. For example, the Vertical Input Attenuator automatically switches the amplifier from wide band to narrow band in the three highest gain positions, and there is enough sensitivity to provide a useful display of the signal from low-level microphones, phono-pickups, and other weak signals found in radio/TV receivers and communications equipment.

One of the more unique features not found on many older scopes is its use as a visual voltmeter. This is done using a screen with a vertical scale marked in volts, together with a built-in voltage-calibrated, frequency-compensated, vertical-input attenuator and an internal calibration source. Sounds complex, but it's easy to use, and allows reasonable measurement of peak-to-peak voltages.

The horizontal sweep frequency control is very limited by modern standards, starting at 15Hz, with four overlapping ranges to only 75KHz. The other controls — sync, vertical and horizontal position and gain, focus, intensity — are standard. A binding post is provided for external sync or horizontal input, the latter of which can be used for frequency matching "Lissajous patterns."

So, while purists may snicker at some of the limitations of this old scope for modern usage with high-frequency digital circuits, it certainly has many uses even in today's electronic environment. Figure 1 is a block diagram of the WO-33 showing the seven vacuum tubes (including the cathode ray tube) and their functions.

Scope Trace Photos

Before plugging in the unit, I

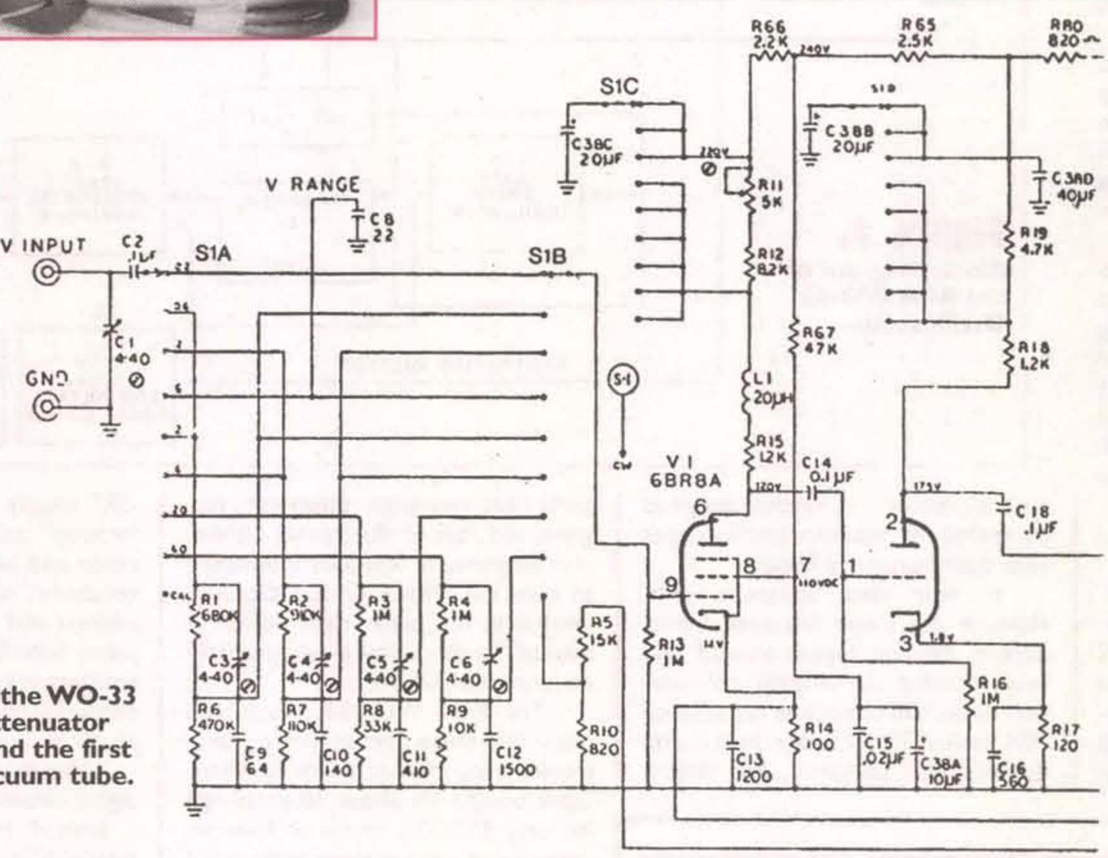
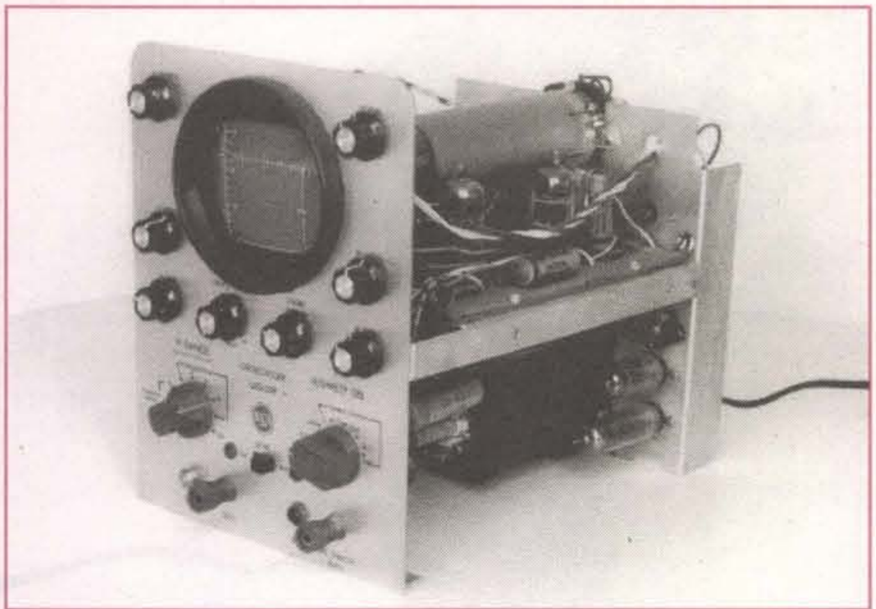


Figure 2.

Partial schematic of the WO-33 shows the vertical attenuator switching network and the first vertical amplifier vacuum tube.



With the case removed, it was obvious this was old technology. The upper section held the cathode ray tube, and four vacuum tubes were mounted on a large printed circuit board together with many associated parts.

asked Steve to describe the problem in detail. "Well, Bob," he began, "it seems to work okay for the first few minutes, then the trace starts distorting, and it gets worse the longer I use it. Here," he continued, "look at these photos. The first photo shows a 400Hz squarewave when I first turned on the scope, then 10 minutes, 20 minutes, and an hour later."

"Hmmm," I responded, "how did you take these photos? They came out pretty good. Not perfect, but pretty good."

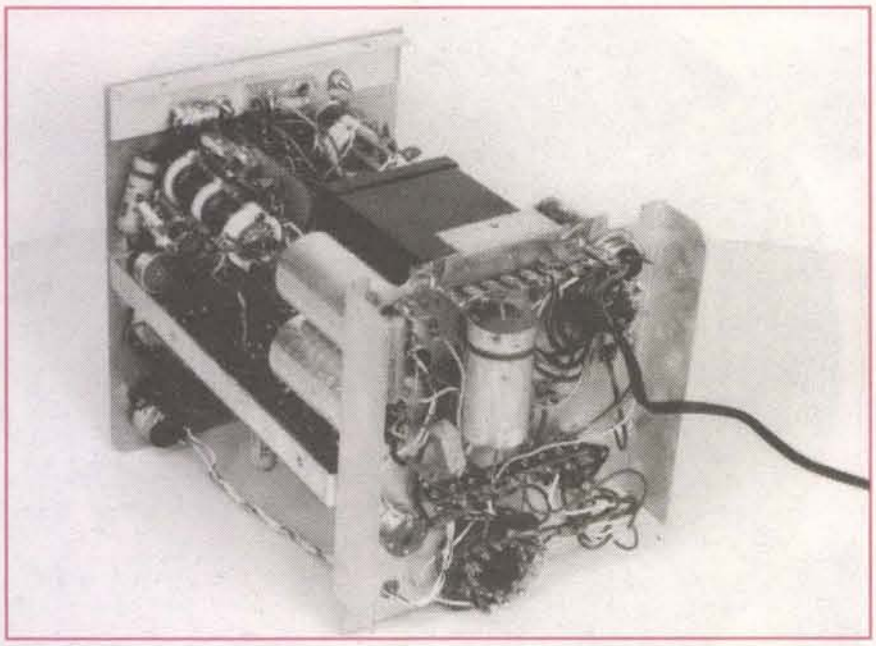
"Oh," Steve answered, "it took me a few rolls of film to get these pictures. I used a 35mm single-lens-reflex (SLR) camera with a cable release and took double-exposures in the dark."

I had some experience with taking pictures of equipment, but not of scope traces. "What kind of film and what exposures?"

"I used Kodak Plus-X Pan black-and-white film with an ASA speed of 125, stopped the lens down to f16 or f22, then set up the scope display with normal brightness. Of course, I used a tripod and set the camera to 'BULB' for time exposures so the shutter stayed open as long as the cable release was depressed."

"Did you need special lenses?" I wondered. "You got in pretty close."

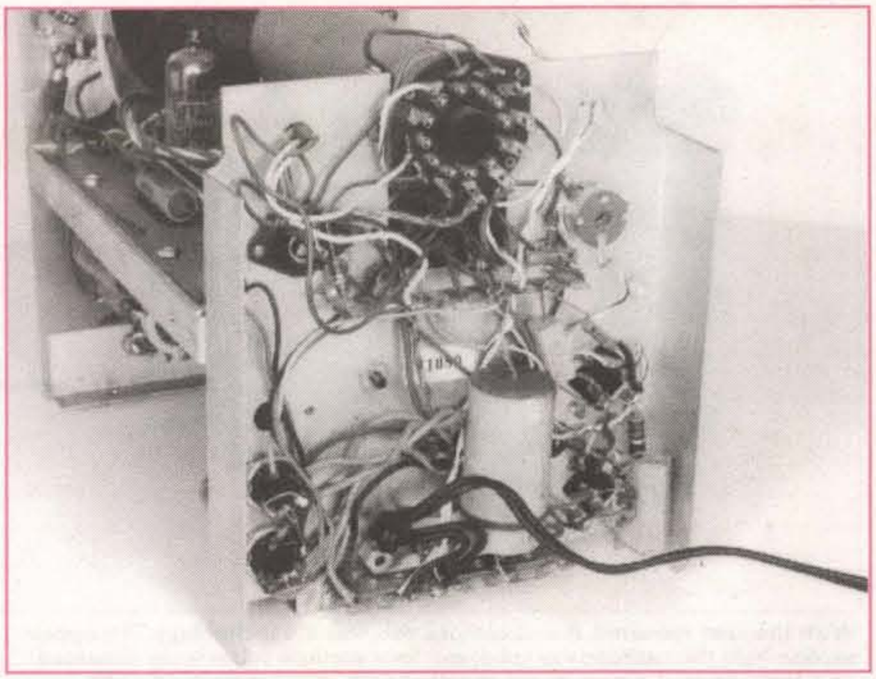
"Yeah," Steve replied. "I used a couple of close-up lenses to focus at nine inches from the face of the scope. I darkened the room, and for a light source I used a 60-watt light bulb in a switched socket at the end of a long line cord plugged into an AC outlet."



The bottom section of the scope held a large transformer, two large filter capacitors, multi-pole switches, and two vacuum tubes.

"Why the light bulb? Didn't that wipe out the scope trace?"

"Well, I wanted to show the scope around the tube area, and the voltage/calibration markings on the face of the tube, so I used a split-time exposure. By that I mean I turned on the light bulb, opened the shutter, waved the light bulb around for three seconds to paint out shadows (being careful to avoid screen reflections). Then I shut off the light so it was dark, but left the shutter open to capture the scope trace. I found that 10 additional seconds exposed the trace about right. Probably eight seconds



The back was a rat's nest of wiring between sockets and terminal strips, with several resistors and another big capacitor.

would have been enough."

"Why so long for the trace? You said you had normal scope brightness," I pondered.

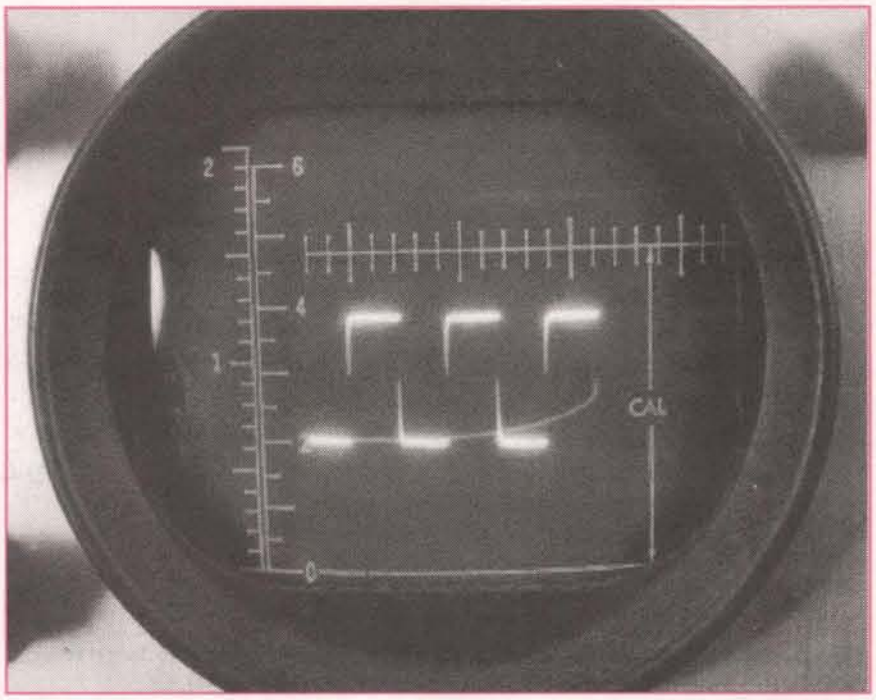
Steve explained that black-and-white film seems "color blind" to the green trace of the RCA scope, which is why he needed the extra "dark" portion of the exposure. "If you are shooting pictures of a blue trace, it might need a different exposure. This was my third roll of film, having tried different exposures on the first two rolls!"

Testing the Scope

The photos Steve gave me showed that the top of a normal squarewave — typical in testing audio equipment and digital circuitry — was tilting downward more and more the longer the scope was operating.

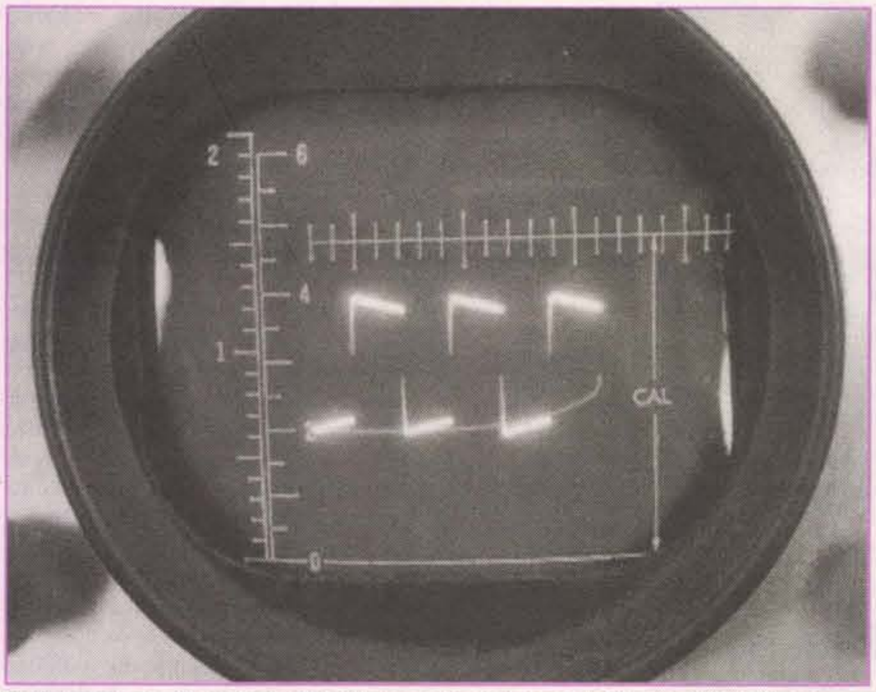
"Hmmmm. What about sinewaves," I asked. "And, Steve, why don't you break down and get a modern scope?"

"Well, Bob, as I recall, sinewaves look okay at first, but sometimes they seem to lose height as the scope warms up. But squarewaves are what I mostly use with my experimenting — simple digital circuitry, signal tracing, you know. I don't need a fancy scope — just something that will give me more information than a voltmeter. I'm not into leading-edge design or high-frequency stuff. I'm just a hobbyist and experimenter, and I'm not sure what I'm doing half the time. And new scopes these days are at least a few hundred dollars! But it bugs me that the squarewave display gets so distorted when the scope is on for awhile."

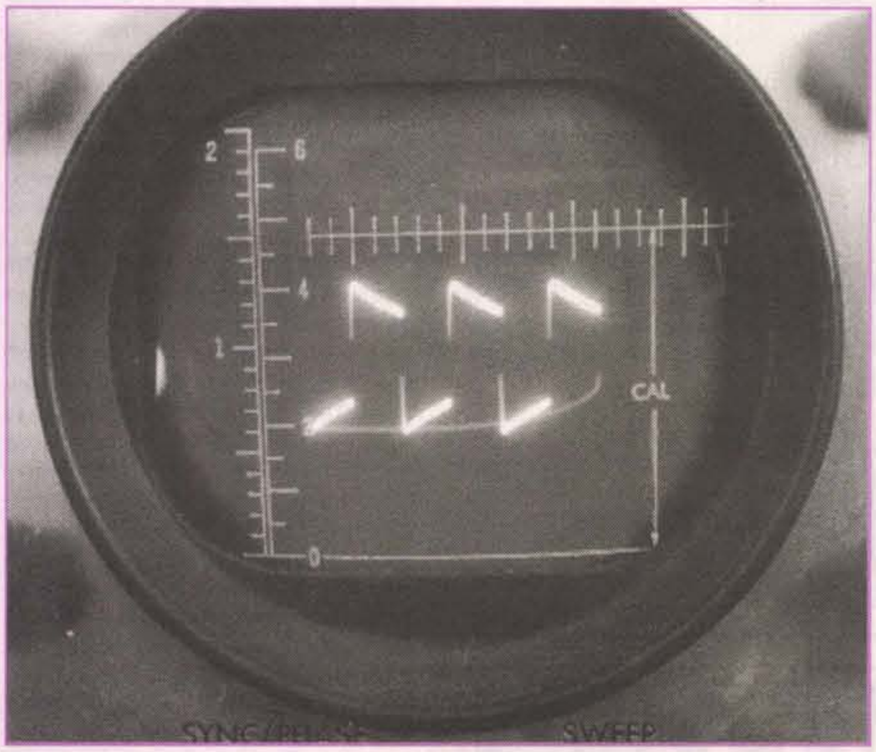


Three cycles of a 400Hz squarewave. Note the retrace on this scope is not fully blanked, and some hum is shown by the thickness of the horizontal portions.

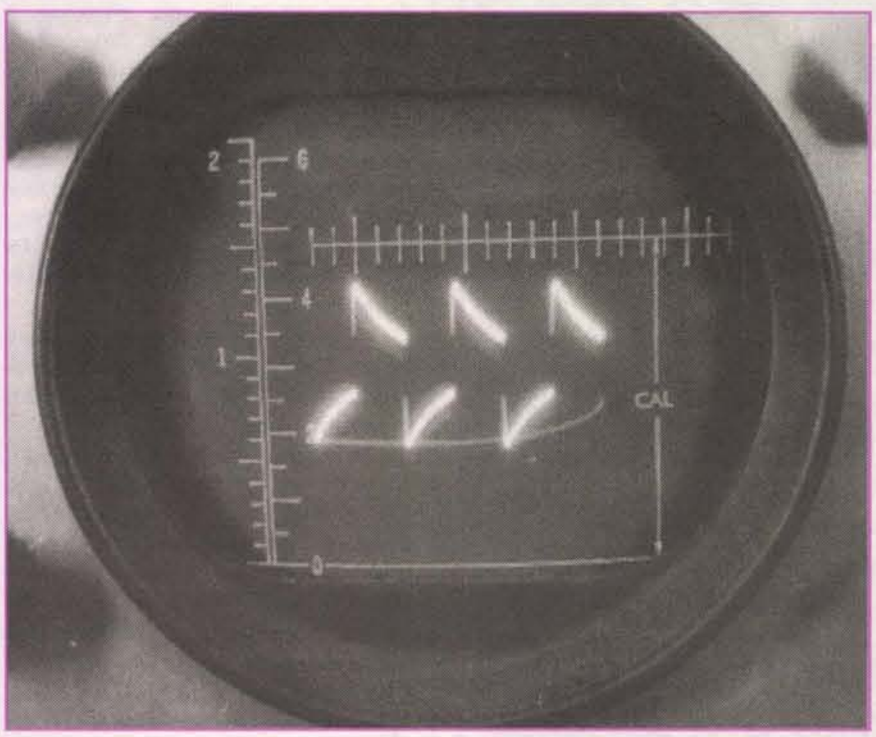
I knew immediately from Steve's photos that the problem was a loss of low-frequency response. This could be caused by an aging tube, a bad coupling capacitor, or possibly even a poor solder joint somewhere in the vertical circuits. The worsening tilt as



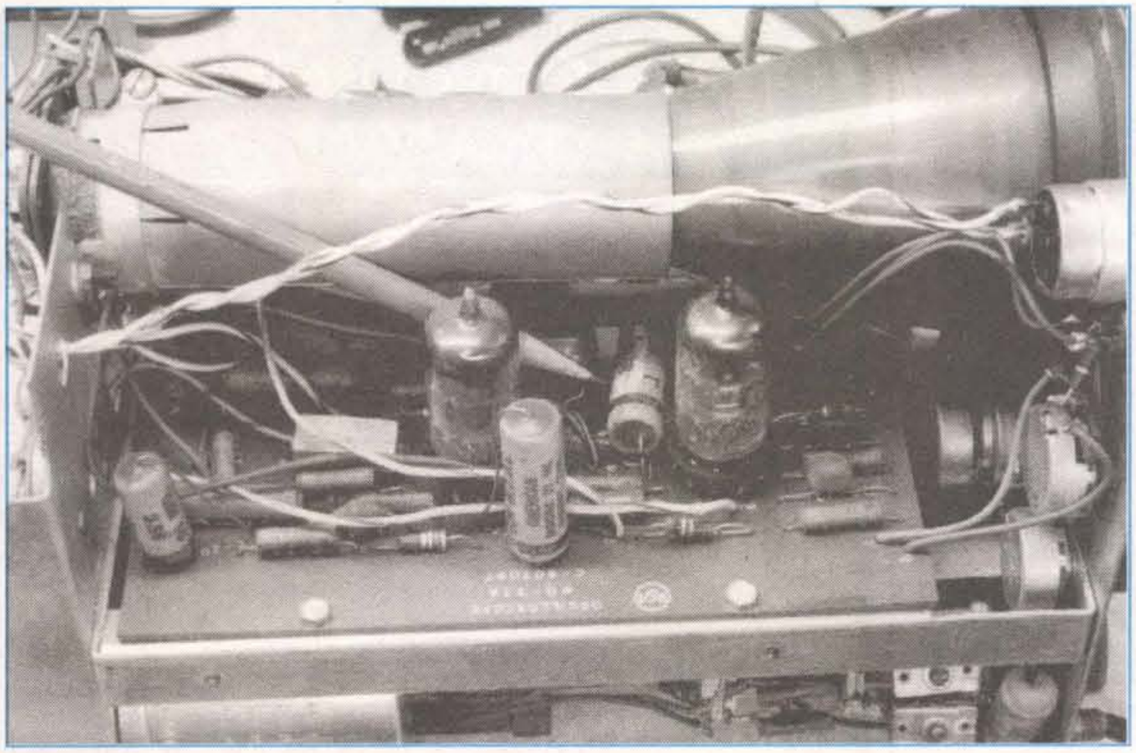
Before repair, after about 10 minutes, the tops and bottoms tilted about 20 degrees.



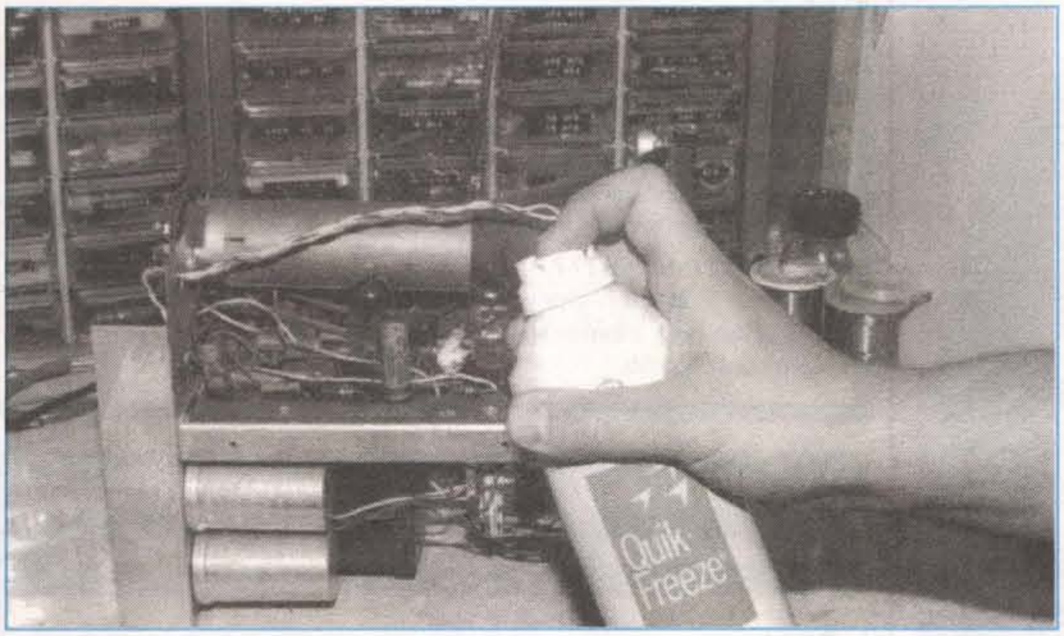
After about 20 minutes, the tops and bottoms tilted about 40 degrees.



After about one hour, the tops and bottoms tilted about 60 degrees.



Using another scope to verify signal integrity, wax-covered capacitor C-14 seemed to be the culprit. Nestled right up against a vacuum tube, it was getting hot and losing capacitance, thus blocking coupling of low frequencies.



A freeze spray was used on C-14 to see if cooling it off would allow a proper squarewave display on the RCA scope. It did!

the unit warmed up also indicated that whatever was wrong was extremely sensitive to temperature. All of the above conditions can be temperature dependent so none could be ruled out (although Steve said he had tried changing tubes).

But I wanted to see for myself. When the line cord was plugged into 115VAC and the OFF/INTENSITY switch/control knob turned clockwise, the typical horizontal line trace appeared in a short time. I fed in a sinewave and then a squarewave at different frequencies as I adjusted the appropriate controls. The traces looked normal; the scope appeared to be operating well enough, although the display showed poor retrace blanking and some hum.

"Yeah, but wait a few minutes. You'll see," Steve chided.

Sure enough, with about a 400Hz squarewave at the input, and three cycles showing steadily, the top of each wave began to tilt down on the right side, as well as the bottom tilting upward, just like Steve's photos.

The cabinet of this compact unit, which had no internal cooling and only a few side and back vents, was getting hot. The problem was obvious — something was changing the vertical circuit bandpass as it got hot. But what?

Removing the cabinet cover involved removing six screws — two on each side and two on the case bottom — and sliding the cover backwards over the rear-extending line cord. The neck of the cathode ray tube — over nine inches long, even though it had only a three-inch diameter face — extended to the rear circuit area. The "guts" of the scope — seven- and nine-pin miniature vacuum tubes, many wax-coated 400-volt capacitors, lots of resistors, switches, and trimmers — were located in three primary areas.

A single, large printed circuit board held four of the vacuum tubes and their associated components; a section underneath the board was devoted to multi-pole switches, a large transformer, two large filter capacitors, and two vacuum tubes; the rear area had several terminal strips, a rat's nest of wires, and the cathode ray tube socket. Except for the printed circuit board, there were wires all over the place running between parts. Ah, the good old days when you could see what was connected to what!

Since I had a schematic (see Figure 2, partial schematic), the obvious approach to troubleshoot this problem would be to "signal trace" the waveform from the probe input towards the vertical plates of the CRT. I used my bench scope to observe the waveform at various points along the vertical amplifier stages of the WO-33A. Starting at the vertical input connector, I verified that the squarewave signal was making it through the probe undistorted. Next, I probed the input to the first vertical amplifier. This signal — at the control

grid of the first section of V1 (pin 9) — looked fine, so the input attenuator and range switch were not causing the waveform distortion.

The output from this first amplifier stage — at the plate, or pin 6 — also looked normal. The signal then passes through coupling capacitor C14 into the next stage (the grid, or pin 1 of the second section of V1). However, when I placed the probe on pin 1, I saw the same tilted waveform that was being displayed on the CRT of the WO-33A.

"Ahah!," I exclaimed as I pointed out to Steve where the problem lay. "Apparently this capacitor is changing value as it heats up. Notice that it is very close to the tube and therefore can get quite hot after the unit has warmed up. To prove that this capacitor is really at fault — and not, for example, a cold solder joint at one of its connections — I'm going to use a can of freeze spray."

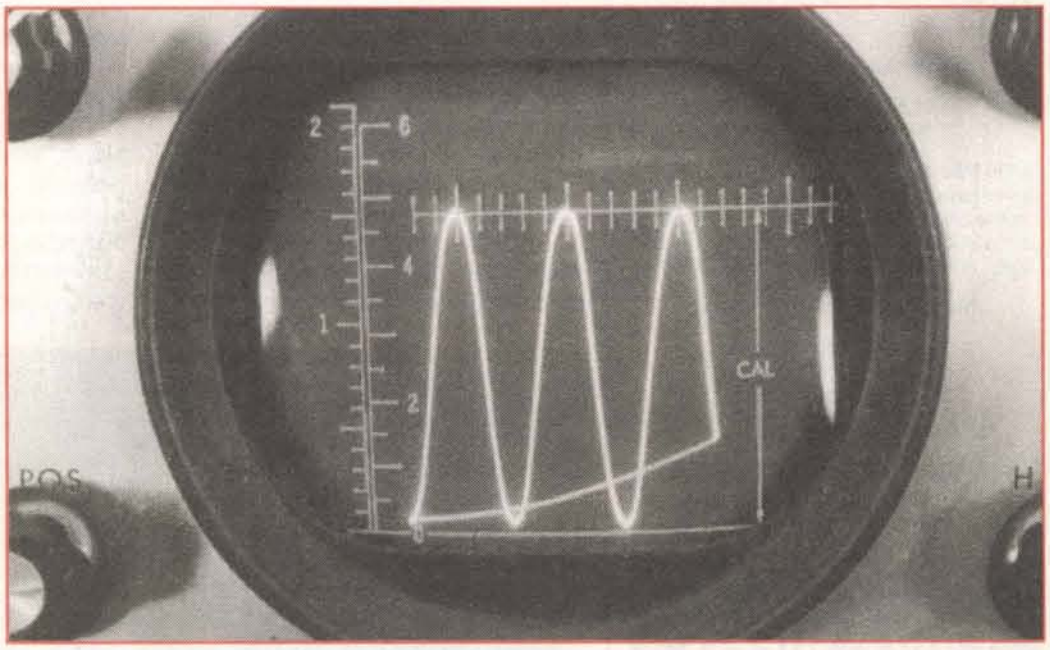
I explained to Steve that many electronic problems are heat-related. Sometimes the problem is directly related to a component's value changing excessively with temperature. Of course, many parts do have a normal "temperature coefficient" which describes the part's behavior at various temperatures. But these effects are usually taken into account when the circuit is designed. The change here was definitely abnormal but nevertheless did exhibit a direct correlation to temperature; the scope trace tilt got worse as the temperature increased.

"Other heat-related problems can show up as intermittents," I explained to Steve. "A common fault is a bad solder connection which becomes intermittently open or capacitive as the temperature changes. Problems like this are often the result of simple mechanical changes due to thermal expansion. Although most problems will show up after being heated (like your scope), it is also possible for a fault to disappear when heated. This explains many of the complaints about equipment that doesn't work when you first turn it on, but then operates okay after being left on for awhile!"

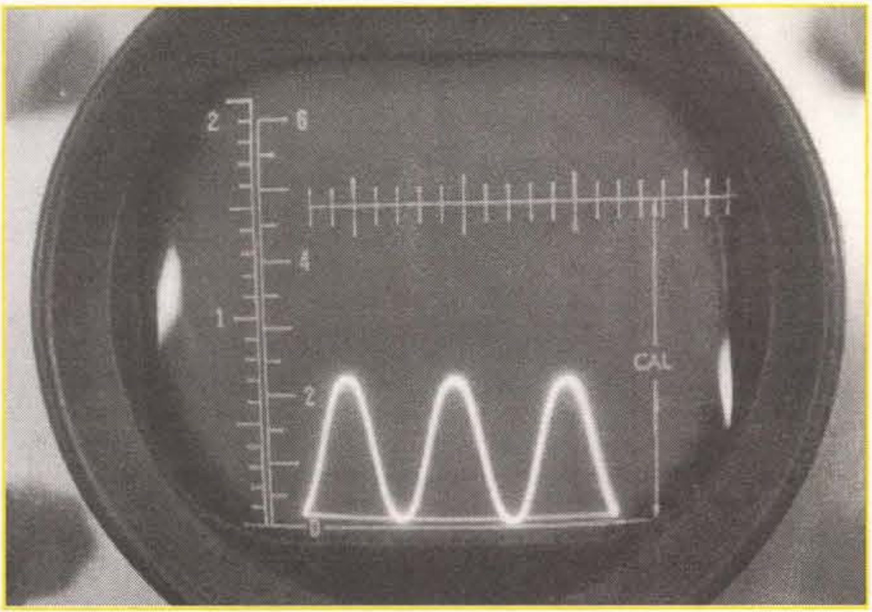
I used a can of Quik-Freeze® (Miller Stephenson item# MS-242) with its pinpoint spray nozzle to selectively cool down just C14. "Notice the frost that forms around the capacitor after just a one-second blast of freeze spray." Although it would take a few seconds for this -60 degree Celsius (-76 degree Fahrenheit) temperature to reach the internal structure of the capacitor, we could see immediately that the waveform on the WO-33A CRT was now correct once more.

Having identified the faulty part, I proceeded to replace C14 with a new 0.1uF, 400VDC capacitor. After that was done, I checked the waveform once more and it was still fine. Just to be sure, I wanted to see the unit operating at its normal high temperature. Instead of waiting another 15

A heat gun was aimed directly at the new capacitor to see if heating it up would cause squarewave distortion. It didn't.



A 60Hz sinewave before the old C14 capacitor heated up and dropped in value.

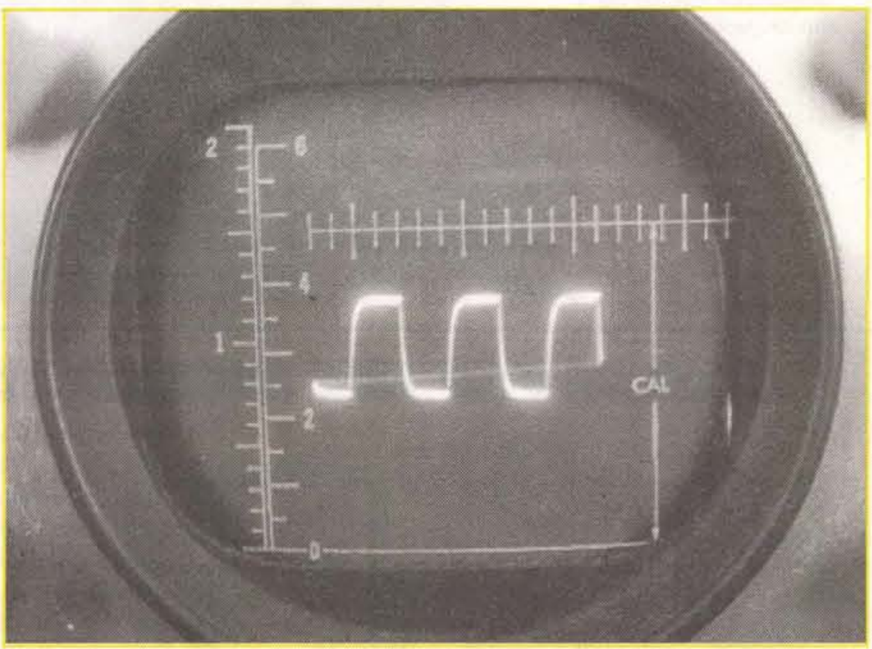


After about an hour, when the old C14 heated up and dropped in capacitance (increasing its resistance to low frequencies), the 60Hz sinewave was about half its former height on the scope display, thus ruining any previous voltage calibration.

minutes for the unit to warm up, I used a heat gun to heat up the entire area around C14. Although any heat gun could be used (even an old hair dryer, if you must), the WAHL Thermal-Spot shown in the photo has the advantage of a slender nozzle for directing the heat to one small area. After thoroughly heating the entire area, no change was observed in the scope trace.

I put the case cover back on, turned on the scope, and once more we watched as the scope heated up. Meanwhile, I explained to Steve that the distorted wave shape he had seen was a clear indication of a drop in low-frequency response, and that the original bad capacitor was dropping in value as it heated up, causing an obstruction (high reactance) to low frequencies being passed from the plate of the first section of the 6BR8A vertical amplifier to the grid of the second section.

Old capacitors of this variety often drop in value or become temperature-sensitive because of changes in the dielectric material. "Recall, Steve, that a capacitor is nothing more than two conducting metal plates separated by an insulating dielectric material. Most cylindrical capacitors consist of fairly large flexible metal plates with a very thin layer of dielectric. The entire 'sandwich' is then rolled into a small tube to conserve space.



Using the connections shown in Figure 4 to attenuate high frequencies, this is what a 400Hz squarewave looks like on the scope.

"The electrical properties of the dielectric," I continued, "are often very dependent upon environmental properties such as humidity, and are therefore sealed from the outside. In this case, the entire original capacitor was covered with wax. If the wax breaks down, or the dielectric leaks out — common in electrolytic capacitors — the capacitor becomes defective."

Everything was working fine. The squarewave was still square after 15 minutes. I looked at Steve and said, "Let me show you what can happen if you put too low a value capacitor in series with a squarewave signal." I connected a capacitor and resistor as shown in Figure 3.

"Wow!" Steve exclaimed. "The trace looks just like it was before you fixed it! Why is that, Bob?"

"Well," I explained, "the low value capacitor presents a higher reactance to low frequencies than to high frequencies." I showed Steve the formula for capacitive reactance:

$$X_C = \frac{1}{2\pi f c}$$

"In this formula, Xc is the capacitive reactance in ohms, f is the frequency in Hertz, and c is the capacitance in farads. You can see from the formula that the reactance, or AC resistance, is inversely proportional to the frequency; the lower the frequency, the higher the reactance."

I continued, "Since a squarewave consists of its fundamental frequency plus many higher harmonics, a circuit must present a relatively flat frequency response to pass the squarewave undistorted. If the lower frequencies are attenuated with respect to the higher frequencies, you'll see a tilt during the flat portions of the squarewaves, as we see here."

"Okay," agreed Steve. "But what would the squarewave look like if the high frequencies were being lost?"

"Ahhh, that can be shown by using this circuit," I said as I showed Steve Figure 4. "We move the resistor into series with the scope input, and put the capacitor across the input, as well as changing the values to show a typical squarewave with the high frequencies rolled off." I hooked up the circuit and the scope trace showed a rounding off at the edges of the squarewave.

"Hmmm," mused Steve. "How does that explain why my sinewaves lost height as the scope heated up, before you changed the capacitor?"

"That's relatively easy to understand," I replied. "Any form of resistance or reactance drops the voltage, so the trace loses height. At a low frequency, a large coupling capacitor in series with the sinewave allows virtually all the signal to get through, but a small capacitance will have a higher reactance at low frequencies and cause a signal loss."

I asked Steve the frequency of the sinewave generator he usually used. He said that he had noticed the loss in height while observing the scope's 60Hz calibration signal. "That's a relatively low frequency," I pointed out. "So when the bad scope capacitor dropped in value, the signal was significantly attenuated. A higher frequency sinewave would be affected less."

Steve left happy, but on the way out he said, "Thanks, Bob. You did it again! With all my old equipment, I'll probably be back soon."

And he was, with an ailing Lafayette SG-10 AF/RF signal generator.

But that's another story ... **NV**

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Sav-On Electronics
13225 Harbor Blvd.
Garden Grove 92643

Sierra Madre Newsstand
55 N. Baldwin Ave.
Sierra Madre 91024

The Red Barn
Hwy. 299
Bieber 96009

Tower Books
211 Main St.
Chico 95928

7840 Macy Plaza Dr.
Citrus Heights 95610

1280 E. Willow Pass Rd.
Concord 94520

630 San Antonio Rd.
Mountain View 94040

1600 Broadway
Sacramento 95818

2538 Watt Ave.
Sacramento 95821

Tower Records/Video
220 N. Beach Blvd.
Anaheim 92801

5703 Christie Ave.
Emeryville 94608

6310 E. Pacific Coast Hwy.
Long Beach 90803

3205 20th Ave.
San Francisco 94132

2525 Jones St.
San Francisco 94133

871 Blossom Hill Rd.
San Jose 95123

Video Electronics
3829 University Ave.
San Diego 92105

CANADA

Cody Books Ltd.
139-3000 Lougheed Hwy.
Westwood Mall
Port Coquitlam, BC V3B 1C5

Com-West Radio Systems Ltd.
8171 Main St.
Vancouver, BC V5X 3L2

Emma Marion Ltd.
2677 E. Hastings St.
Vancouver, BC V5K 1Z5

Muir Communications Ltd.
3214 Douglas St.
Victoria, BC V8Z 3K6

COLORADO

Centennial Electronics, Inc.
2324 E. Bijou
Colorado Springs 80909

Tower Records/Video
2500 E. 1st Ave.
Denver 80206

CONNECTICUT

Archway News
64 Bank St.
New Milford 06776

DELAWARE

Newark Newsstand
70 E. Main St.
Newark 19711

DISTRICT OF COLUMBIA

Tower Records
2000 Pennsylvania Ave.
Washington 20006

FLORIDA

Alfa Electronic Supply
6444 Pembroke Rd.
Miramar 33023

Astro Too
6949 W. Nasa Blvd.
West Melbourne 32904

Clarks Out of Town News
303 S. Andrews Ave.
Fort Lauderdale 33301

Mike's Electronic Distributing Co.
1001 N.W. 52nd St.
Fort Lauderdale 33309

Skycraft Parts & Surplus, Inc.
2245 W. Fairbanks
Winter Park 32789

Sunny's At Sunset, Inc.
8260 Sunset Strip
Sunrise 33322

GEORGIA

Tower Records
3400 Around Lenox Dr. N.E.
Atlanta 30326

HAWAII

SolarWorks!
525 Lotus Blossom Ln.
Ocean View 96737

Tower Records
4211 Waialae Ave.
Honolulu 96816

611 Keeaumoku
Honolulu 96814

IDAHO

The Current Source
5159 Glenwood
Boise 83714

ILLINOIS

Tower Records/Video/Books
383 W. Army Trail Rd.
Bloomingdale 60108

2301 N. Clark St. #200
Chicago 60614

1209 E. Golf Rd.
Schaumburg 60173

INDIANA

Harbourtown Sales
108 Park 32 W. Dr.
Noblesville 46060

KANSAS

Hollywood At Home
9063 Metcalf Ave.
Overland Park 66212

Lloyd's Radio & Electronic, Inc.
220 W. Harry St.
Wichita 67213

LOUISIANA

Lakeside News
3323 Severn Ave.
Metairie 70002

MARYLAND

Tower Records/Video
2566 Solomons Island Rd.
Annapolis 21401

1601 Rockville Pike #210
Rockville 20852

MASSACHUSETTS

Newsbreak, Inc.
579 G.A.R. Hwy. Rt. 6
Swansea 02777

MICHIGAN

Little Professors Book Center
22174 Michigan Ave.
Dearborn 48124

Purchase Radio Supply, Inc.
327 E. Hoover Ave.
Ann Arbor 48104

MINNESOTA

Radio City, Inc.
2633 County Road 1
Mounds View 55112

MISSOURI

Accurate Instruments
11201 E. 24 Hwy.
Independence 64054

Electronics Exchange
8644 St. Charles Rock Rd.
St. Louis 63114

NEVADA

Amateur Electronic Supply
1072 N. Rancho Dr.
Las Vegas 89106

Less Buster's Electronics
2930 N. Las Vegas Blvd.
VSTG-22
North Las Vegas 89030

Radio World
1656 Nevada Hwy.
Boulder City 89005

Tower Records/Video
4580 W. Sahara Ave.
Las Vegas 89102

6450 S. Virginia
Reno 89511

NEW YORK

All Phase Video Security, Inc.
70 Cain Dr.
Brentwood 11717

Computer Warehouse
137 E. Bridge St.
Oswego 13126

Ham Central
3 Neptune Rd.
Poughkeepsie 12601

Hirsch Sales Corporation
219 California Dr.
Williamsville 14221

Tower Records/Video
105 Old Country Rd.
Carle Place 11514

350-370 Route 110
Huntington 11746

1961 Broadway
New York 10023

383 Lafayette St.
New York 10003

OHIO

Bank News
4025 Clark Ave.
Cleveland 44109

Compustuff
241 Great Oaks Trl.
Wadsworth 44281

Footsteps
4925 Jackman Rd. Store #58
Toledo 43613

Hosfelt Electronics, Inc.
2700 Sunset Blvd.
Steubenville 43952

Keyways, Inc.
204 S. 3rd St.
Miamisburg 45342

Leo's Book Shop
333 N. Superior St.
Toledo 43604

Powermaxx, Inc.
1587 U.S. Route 68 N.
Xenia 45385

OKLAHOMA

Steve's Books & Magazines
2612 S. Harvard
Tulsa 74114

Taylor News & Books
133 W. Main, Ste. 102
Oklahoma City 73102

OREGON

News & Smokes
1060 S.E. M St.
Grants Pass 97526

Norvac Electronics
7940 S.W. Nimbus Ave. Bldg. 8
Beaverton 97005

960 Conger
Eugene 97402

1545 N. Commercial N.E.
Salem 97303

Tower Books
1307 N.E. 102nd Ave.
Portland 97220

PENNSYLVANIA

Bedford St. News
308 Bedford St.
Johnstown 15901

Tower Books
425 South St.
Philadelphia 19147

Tower Records
340 W. Dekalb Pike
King of Prussia 19406

TENNESSEE

Tower Books
2404 W. End Ave.
Nashville 37203

Tower Records
504 Opry Mills Dr.
Nashville 37214

TEXAS

BDL News, Inc.
809 Pierce
Houston 77002

Electronic Parts Outlet
3753-B Fondren Rd.
Houston 77063

Mouser Electronics
958 N. Main St.
Mansfield 76063

Tanner Electronics
1301 W. Beltline #105
Carrollton 75006

Tower Records
2403 Guadalupe St.
Austin 78705

VIRGINIA

Tower Records/Video/Books
4110 W. Ox Rd. #12124
Fairfax 22033

1601 Willow Lawn Dr.
Richmond 23230

8389 E. Leesburg Pike
Vienna 22182

WASHINGTON

A-B-C Communications, Inc.
17541 15th Ave. N.E.
Seattle 98155

Service Request
3304 W. Rowan Ave.
Spokane 99205

Supertronix
16550 W. Valley Hwy.
Seattle 98188

Tower Books
10635 N.E. 8th St.
Bellevue 98004

20 Mercer St.
Seattle 98109

WISCONSIN

Amateur Electronic Supply, Inc.
5710 W. Good Hope Rd.
Milwaukee 53223

Greenfield News & Hobby
6815 W. Layton Ave.
Greenfield 53220

Cudahy News & Hobby Ctr.
4758 Packard Ave.
Cudahy 53110

WYOMING

Western Test Systems
2701 Westland Ct. #B
Cheyenne 82001

ELECTRONICS Q&A

With TJ Byers

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist. Feel free to participate with your questions, as well as comments and suggestions. You can reach me at: ***TJBYERS@aol.com*** *or by snail mail at Nuts & Volts Magazine, 430 Princeland Ct., Corona, CA 92879.*

What's Up:

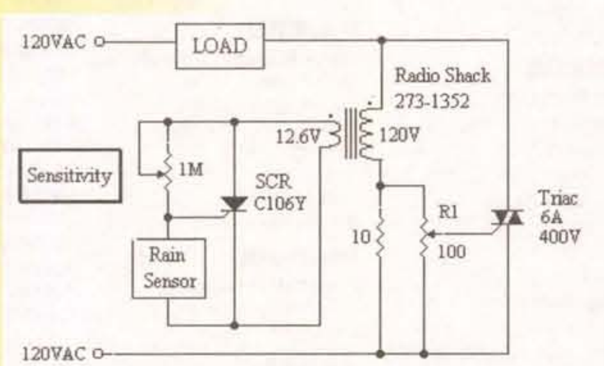
Meters, meters, meters: sound level, ESR, capacitance. Rain controller and RF remote controller. Computer topics include dual displays for Windows 98 and forced retirement for the old timers.

Rain Sensor

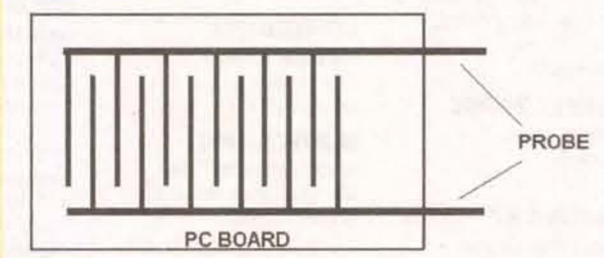
Q. I'm looking for a circuit to turn off my outdoor bug zapper when it starts to rain or when I water the lawn. I want the zapper to turn back on when the sensor is dry. The sensor I have in mind is just a wire grid, like the kind used for under-sink and water heater alarms.

Ray Samples
Fayetteville, NC

A. The following circuit is very simple and very safe because the transformer isolates the sensor grid from the AC load.



When the sensor is dry, the SCR turns on and saturates the transformer, which lets AC pass through the triac. When moisture comes in contact with the sensor, both the SCR and the triac turn off. For the sensor grid, I'd use the printed circuit board pattern below.



To calibrate the controller, make sure the sensor is dry and adjust R1 until the load just turns on (a small lamp across the zapper makes a good visual indicator). Then apply moisture to the sensor and adjust the sensitivity control until the load goes off. Enjoy!

Dual Windows 98 Display

Q. Apparently, Windows 98 has the ability to run two display cards and two monitors. If this is true, it opens up some interesting possibilities. One that interests me would be the ability to run two screens of instrumentation (virtual meters, etc.) in Visual Basic. Another use could be one screen of instrumentation and the other screen with tabular data (or spreadsheet). Anyway, it sounds neat, but I don't know the details. Are you familiar with this?

Sid Knox
Helios Systems
Welling, OK

A. Yes, Windows 98 does support two video cards and two monitors — something Mac users have known the pleasure of for years. Unfortunately, getting two monitors to work with Windows 98 properly isn't an easy chore. Let me see if I can simplify it.

Step 1: Make sure you have two compatible video cards. It doesn't matter whether the card plugs into an ISA or PCI slot, the criteria is that they are compatible and can work together; Windows PnP (Plug n' Play) compatibility is a plus.

Step 2: Make sure that both video cards have a driver that supports dual monitor display. Most major graphics card makers have compatible drivers on their web sites, but not necessarily for all cards. It's best to do the legwork before you go to all the trouble of installing the second card.

Step 3: With power off, install the second video card. Connect to the second monitor and power up the monitor. It's very important that both monitors are turned on before you apply power to the PC.

Step 4: Turn on the PC (monitors engaged).

Step 5: This is the hardest part — determining which is the primary monitor. Generally, it's the card plugged into the PCI number one slot, but not necessarily. Chances are good you'll get a Windows 98 screen, but setting up the graphics can be a chore. Move the cursor arrow to the program (Start) bar, click the right mouse button, and choose the Properties option.

Step 6: Sorry to say, beyond this step you're on your own. If needed, contact the video card vendor or **DriverGuide** at **www.driverguide.com** for a recent driver that's capable of multi-monitor support.

Monitor Troubles

Q. I own an NEC MultiSync 3FGx monitor that I bought from a garage sale a while ago. Unfortunately, I discovered that it seems to have a slight defect. The problem is that in high-resolution modes, specifically at 800 x 600 and 1024 x 768, it gets blurry. This starts to happen about five minutes after I turn it on, and only around the perimeter of the screen. After half of an hour, the fuzziness starts to creep to the center of the screen. What could the problem be with this monitor, and is it possible for me to fix it? All other monitors work normally on this computer, so the problem must with the monitor.

Tyler Graff
via Internet

A. Unfortunately, I've had very bad luck with NEC MultiSync 3FGx monitors, most of which has to do with filling the screen with a full picture. Yes, I can fix it using a diddle stick by tweaking the horizontal size coil, but the fix is never permanent. Your problem, too, is simple: The focus voltage is shifting, which is causing the fuzziness you see at the edges. Solution? More ventilation (cooling) or — my suggestion — a new monitor.

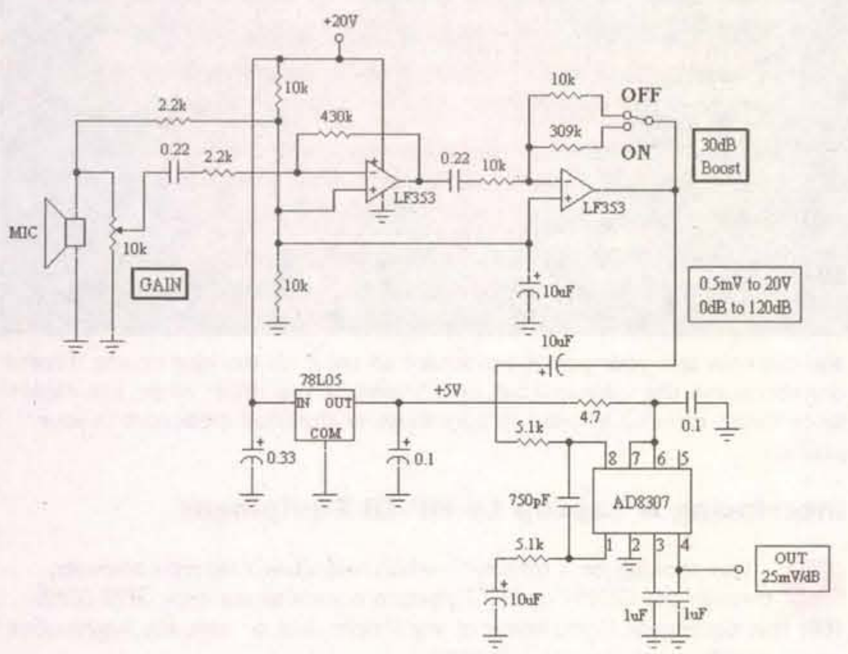
Keep It Down!

Q. I just got back from our family's annual ski weekend. We congregate in one of the rented houses for every meal, with the number of people sometimes topping 40 and more, including children. During brief moments of blessed silence, I wondered what the sound level of the dining area was at different times of the day. A perfect experiment for PIC-based data loggers, which are plentiful and affordable. However, my analog skills are weak, so I wanted to get some help with a sound level sensor.

Here's what I envision for the logger: The logger would take sound level samples once per minute, with each sample tied to the time of day. The sound level scale should be in absolute values (i.e., 25 to 100 dB), as opposed to relative audio levels (-3, -1, 0, +1, +3 dB). The sensor's output should be geared towards the A/D converters in PICs, which I think is 0-5 volts. Is this something that you can help me with?

Richard Cini
via Internet

A. The input range of most data loggers is 0 to 4.096 volts, which isn't a problem as you will see as I describe the sound level sensor.



Ambient sounds are picked up by the microphone and fed to the input of the first op-amp. The second op-amp sets the range of the sound level by a factor of 1 to 33, depending on the setting of the switch. The signal is then input to a logarithmic amplifier for output to the PIC or other instrument.

The reason sound uses a logarithmic scale is because the human ear responds to sounds in a non-linear way. The human ear is more sensitive to small changes than it is to gross sound level changes. For example, if two sound sources of 0 dB each were added together, the result would be 3 dB, yet, if two sound sources of 80 dB each were added together (two noisy bands), the result would be 83 dB (3 dB being the lowest level we can hear a change in "volume"). As you can see, at any level, our ears can hear the faintest difference between sounds while ignoring the overall ambiance. If our hearing were linear, it would be limited to a range roughly between whispers and quiet conversation — anything outside these limits would be too loud to determine its source or direction, or go unheard. Not good for gatherers and hunters. Experiments by German physiologist Ernst Heinrich Weber and Alexander Graham Bell determined that hearing is logarithmic, a range that stops just short of 200 dB.

Human Ear Typical Sound Level Range

dB Level	What It Is
140 dB	Aircraft carrier deck
130 dB	Nearby (one block) air-raid siren
120 dB	Threshold of pain, rock band concert, hearing damage
110 dB	Jet plane takeoff, thunder clap
100 dB	Power mower, motorcycle
90 dB	Blender
80 dB	Dishwasher, alarm clock
70 dB	Vacuum cleaner, noisy restaurant
60 dB	Normal conversation (no family fights)
50 dB	Clothes dryer
40 dB	Library
30 dB	Whisper from five feet away
20 dB	Rustling leaves
10 dB	Sound of your own breathing (without a cold)
0 dB	Threshold of hearing

To use the sound-level meter, the output voltage of the microphone must be brought into range of the AD8307 logarithmic amplifier. But to get that range, you need a voltage swing of 0.5 mV to 20V — quite a chore for the microphone preamp circuit. Which is why there are two controls in that section. The GAIN control is the main adjustment, and sets the voltage output of the first stage. The next amplifier stage has two settings: one in which the signal passes through unamplified, and a setting where the signal is boosted by 30 dB. From here the signal goes to the log amp, where it emerges as a linear signal. From here you can process the signal via your PIC data logger, or display device.

The meter is calibrated by using the dB sound level chart above. If the ambient sound range is 0 dB to 120 dB, the output from the log amp should be 0.5 to 2.5 volts, which means a 60 dB source should read 1.5 volts (25 mV x 60 dB = 1.5 volts). Adjust the GAIN and 30 dB boost controls so that the output voltage corresponds to the input sound level. This voltage is then input to the data logger. As I said, most microprocessor ADCs have an input range of 0 to 4.096 volts, but this range is adjustable. You can adjust the voltage span in either hardware — by changing the gain of the input amp — or in software.

I've never tried this design, just going by the books, so some fine-tuning may be needed. For example, if you can't get the input voltage to the log amp into the desired range, the value of the 309k feedback resistor (Rf) of the 30 dB boost amp can be adjusted up or down. The formula is gain = Rf /10,000; for example, if Rf equals 100k, then the voltage gain is 10 (20 dB). By the way, if you can live with a narrower dB range, the +20V line can be reduced to nine volts, and the current requirement is low enough that a nine-volt battery will power the circuit sensor for a few hundred hours.

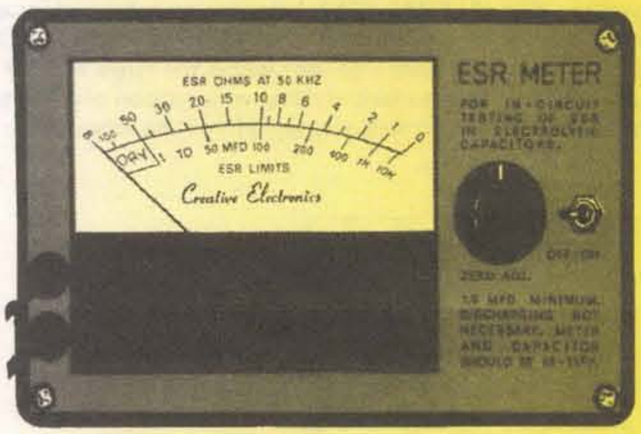
Electrolytic Capacitor ESR Meter

Q. I see ads for "in-circuit" ESR meters that check for defective electrolytic capacitors. Is this a device that can be constructed by the average hobbyist? Do you know where one might obtain a schematic?

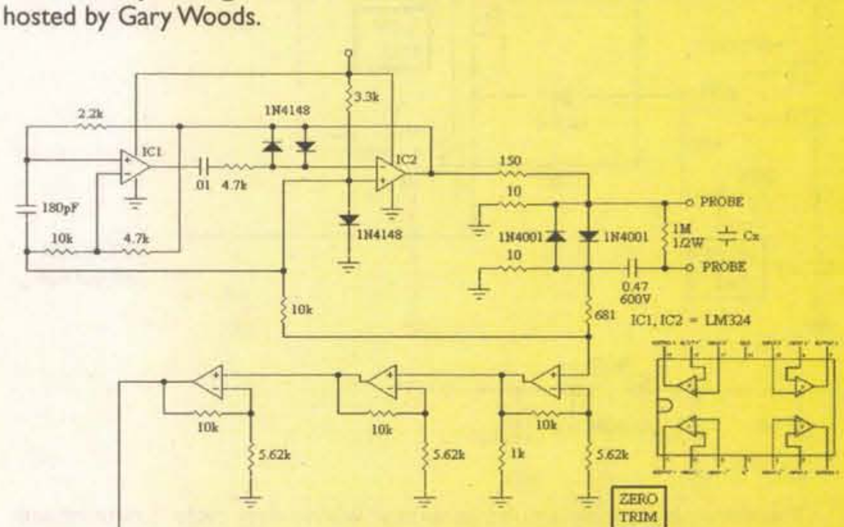
Ken Olsen
via Internet

A. The ESR meter is basically an AC ohmmeter that provides a reading of the Equivalent Series Resistance in an electrolytic capacitor. Most electrolytics fail not because of changes in their capacitance, but in a change of their ESR. As an electrolytic ages, the "paste" that separates the plates changes properties — mostly by drying out, and sometimes by separation from the plates (bubbling). This change doesn't normally affect the measured capacitance, but greatly increases the ESR which, in turn, reduces the filtering properties of the cap and renders it unusable.

Most in-circuit ESR meters are digital devices that cost about $150.00, but many hobbyists maintain that the best ESR meter was an analog instrument made by Creative Electronics, a company that has since gone out of business.



Fortunately, I was able to find a description and schematic of this gem at **www.albany.net/~gwoods/esr_meter/esr_meter_index.html**, a web site hosted by Gary Woods.



While most parts aren't critical, 1% resistors are recommended, and the capacitors should be hi-Q ceramics. Two critical parts are found in the

PROBE. The 0.47uF cap must have a DCWV of at least 200 volts, with 600 volts recommended. This cap isolates the ESR meter from the circuit, which can be live during testing (not highly recommended). The 1M bleeder resistor across the PROBE tips has to be half-watt or better. Calibration of the meter essentially consists of tweaking the ZERO NULL and ZERO TRIM controls until the meter reads — well, zero — with the probes waving in air (unconnected).

There are a lot of opinions on how much ESR an electrolytic can have and still be good. I've culled through the suggestions and read the manufacturer's specs, and came up with the following table.

ESR Value (ohms)	Capacitance Value	Action
over 50	Any electrolytic	Replace
20 to 50	1.0 to 50 uF	Okay
over 10	100 uF	Replace
over 1	1000 uF	Replace
over 0.1	10,000 uF	Replace

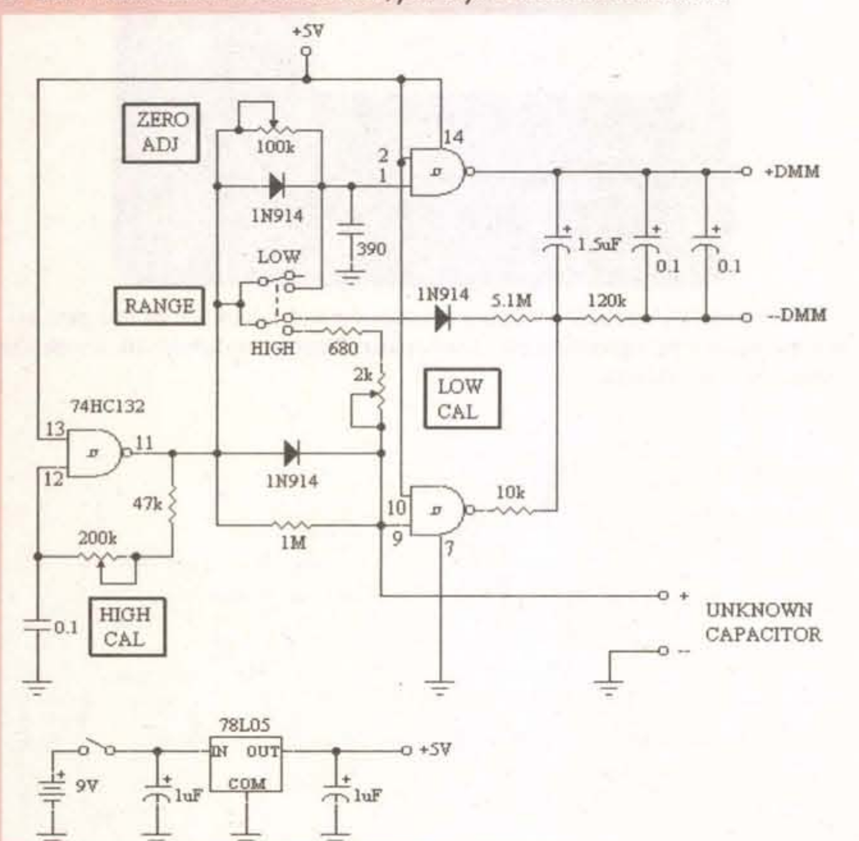
These are only general guidelines, though, because other factors play into the reading. For example, a shorted capacitor measures as good, and it's impossible to spot a bad capacitor in a paralleled array. For this, you need a capacitance meter, like the one in the question below.

Capacitance Meter On The Cheap

Q. My avocation is antique outboard motors — the kind with points and condensors to create the spark. I'm trying to find a test device for condensors or a schematic for one that I could build. I've seen such a device on someone's workbench a long time ago, but I'll be darned if I can remember who it was! Any ideas on where I could find something like this?

John Puffer
via Internet

A. **Rainbow Kits (317-291-7262; http://www.rainbowkits.com)** makes a capacitance meter, model CA-1 ($12.95), that uses a DMM to display the value of any unknown capacitor within the range of 2.2pF to 2.2uF. This instrument can be used to test whether your ignition condensor is good or bad. Wanna build it from scratch, you say? Here's the schematic.



The circuit is basically a pulse generator whose duty cycle is determined by the value of the unknown capacitor. As the value of the capacitor increases, the duty cycle also increases, which the DMM integrated into an average. Because the average output voltage is linear and proportional to the value of the unknown capacitor, its value can be directly displayed on the DMM. To calibrate the capacitance meter, set the DMM to the two-volt scale, apply power (turn on the nine-volt battery switch), flip the RANGE switch to LOW, and adjust ZERO ADJ to read zero volts. Connect a 1000pF capacitor (.001uF) across the input terminals and adjust LOW CAL so that the DMM reads 1.000 volts. Set the RANGE switch to HIGH, connect a 1.0uF capacitor across the input, and adjust HIGH CAL so that the DMM reads 1.000 volts. That's it.

Cool Web Sites

Mad Scientist Network — www.madsci.org
Provides answers to science questions, edible, and inedible experiments.

QuickBrowse — www.quickbrowse.com/qbsearch
Tired of rippling through googles of Google or Yahoo pages? Try this.

Geoskills — www.geoskills.com
Offers links to tutorial sites that help you learn computer programming, web development, and study skills.

Elderhostel — www.elderhostel.org
Providing high-quality, affordable, educational adventures for adults who are 55 and older.

You can now test your points condensor to see if it's working or not. If memory serves me, the value is 0.5uF, or 0.5 volts on the HIGH range. The capacitance meter can also be used to sort those unidentified capacitors in your junkbox.

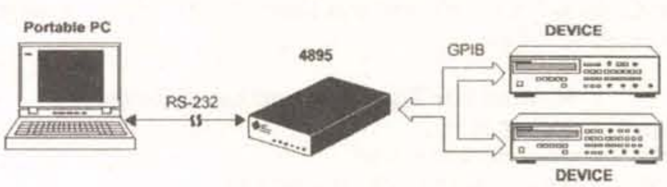
Interfacing A Laptop to HP-IB Equipment

Q. I am looking for a schematic which will allow a laptop computer, through the COM1 or LPT1 port, to communicate with GPIB (IEEE-488) test equipment. If you know of any articles, kits, or have any suggestions, I would greatly appreciate the information.

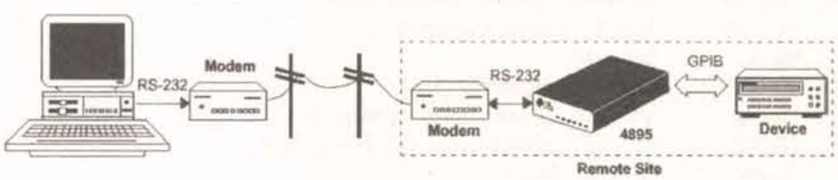
Jeffrey Shank
York, PA

A. Well ... there's a lot more to this story than a simple interface circuit. To begin with, the IEEE-488, also known as HP-IB (Hewlett-Packard Interface Bus) or GPIB (General-Purpose Instrumentation Bus), was originally introduced by Hewlett-Packard in 1965 as a polled parallel interface — something like a SCSI port, only much more ambitious. Essentially, the bus consists of talkers, listeners, and controllers. The controller is the brains of the system; it programs the test instruments and directs data traffic. The instruments are the listeners and talkers.

ICS Electronics (408-263-5500; http://www.icselect.com) makes a GPIB to RS-232 serial interface adapter. In fact, they make two: the Model 4894A and the 4895. The 4894A is essentially a talker/listener with limited controller commands, while the 4895 is a stand-alone GPIB controller that incorporates the new IEEE-488.2 protocols and SPCI commands.



Connecting the 4895 to any computer's com port adds full GPIB capability to the computer. The 4895 is an easy way to interface a notebook computer with the GPIB bus.



By adding modems, the computer can use the phone line to communicate with the 4895 and control devices at the remote site.

For your application, though, I recommend a PCMIA (PC Card) card, like the PMC-GPIB from **ComputerBoards (508-946-5100; www.computerboards.com)** or the 488-PCM from ICS Electronics; both have a price tag of $299.00. They're smaller, faster, and cheaper than the 4894A or 4895 — furthermore, they're hot-swap Plug-n-Play (which means you can insert and remove them without turning off the PC). Your other choices are ISA and PCI controller cards from companies like **Agilent Technologies (1-800-403-0801; www.agilent.com/Top/English/index.html)**, ComputerBoards, and **IOtech (440-439-4091; www.iotech.com)**. Prices range from $249.00 to $499.00, depending on the speed and slot type. Oh, and don't forget the software. Favorites are DASYLab **(DASYtech; www.dasytec.com)**, HP-VEE (Agilent Technologies), and LabVIEW **(National Instruments; www.ni.com/labview)**.

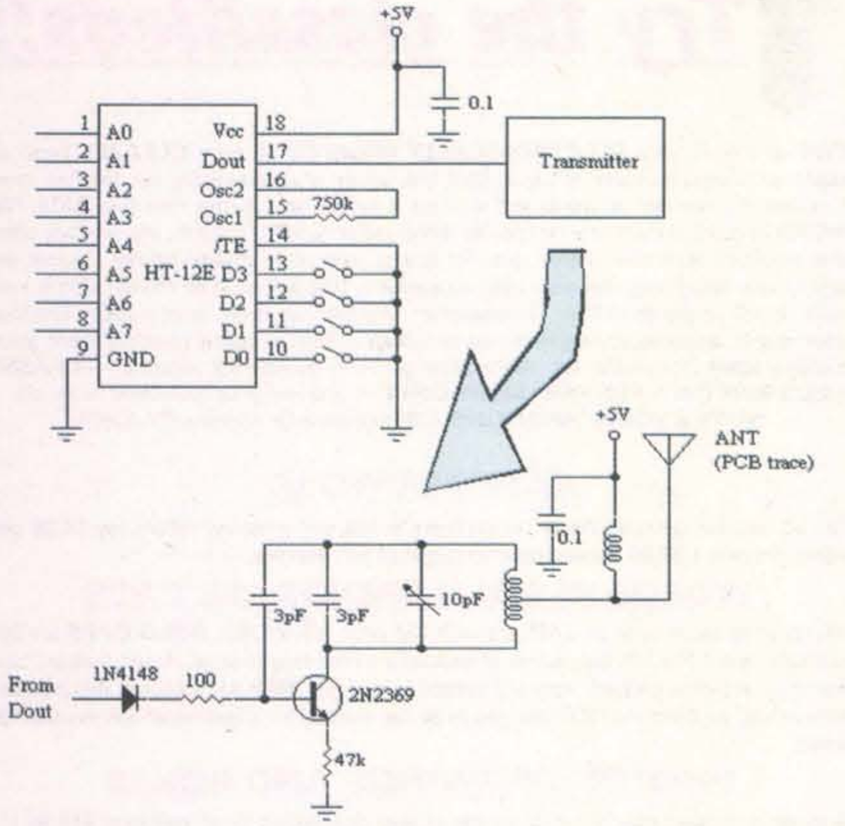
RF Wireless Remote Control

Q. I'm interested in building a radio-controlled switch to turn devices on and off — things like coffee makers, lawn sprinklers, etc. Actually I just need to open and close a 12-volt relay. From there, I can use a high power

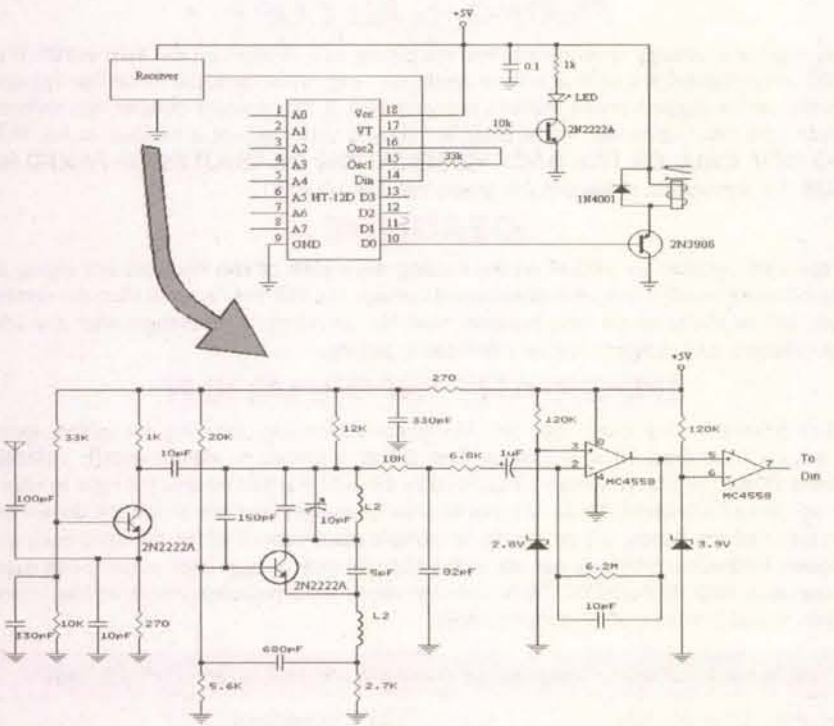
solid-state relay to control the appliance. What I'm looking for is a set-up similar to a television remote control, but one that can go between walls, i.e., infrared isn't the answer.

Albert Lovecky
via Internet

A - Most RF wireless controllers are built around Holtek HT-12E encoder and HT-12D decoder chips. You can buy them from **Digi-Key (1-800-344-4539: www.digikey.com)** or **Tech America (www.radioshack.com)** for under $2.00. Here are the circuits.



Wireless RF Transmitter



Wireless RF Receiver

The schematics of the transmitter and receiver, models TX-99 and RE-99, are courtesy of **Ming Microsystem (home.att.net/~wzmicro/ming_rf_xmitter_receiver.htm)**; circuit boards for these projects are available from Digi-Key for $10.00 and $11.68, respectively. With the exception of the resistors on pins 15 and 16 of both ICs, which should be 1% to guarantee stability, the part values aren't critical and reasonable substitutions can be made without loss of performance. Range is about 50 feet, but can be extended to a few hundred feet with a suitable antenna. The D0 through D3 data lines are selectable and can be used to remotely control up to four separate appliances. The SPST switches in the HT-12E schematic select the transmitted data line and the relay driver shown on D0 of the HT-12D receiver schematic is typical of the drivers used on all four data outputs. The LED lights when a valid signal is received, regardless of the data line selected. If this sounds overly ambitious, you can buy a wireless door bell that uses the same Holtek chips and is already assembled for about $20.00. Simply replace the bell ringer with a suitable relay.

Yet Another ATX Challenge

Q - I have an IBM Aptiva model 2144-A10 Pentium 100 that will not power up (power LED comes on for about 30 seconds, then shuts down). My thinking is the power supply is bad, but at $250.00 for an IBM replacement, the computer isn't worth it! Can I substitute an ATX power supply, and how do I change the pinout to match?

Tim LeMaster
via Internet

A - Let me first say that I doubt the power supply is the culprit. Furthermore, why would you want to replace an AT power supply with an ATX power supply when most computer shops are giving away AT power supplies for free? My suggestion: Start again with a new system. I was walking down the street the other day, on my way to the market, and ran across four garage sales — including one from a PC retail vendor — who had boxes of old PC hardware that said "TAKE ME HOME — PLEASE" sitting on the sidewalk. And it was all free! No kidding! Bottom line, the PC market is moving way too fast, and you can upgrade your system for as little as $300.00 (check out www.ebay.com). But you already knew that when you said that a $250.00 repair was too much to pay for a Pentium 100 system. I agree.

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Keith Blair
via Internet

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Product/Category INDEX

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Continued from page 61

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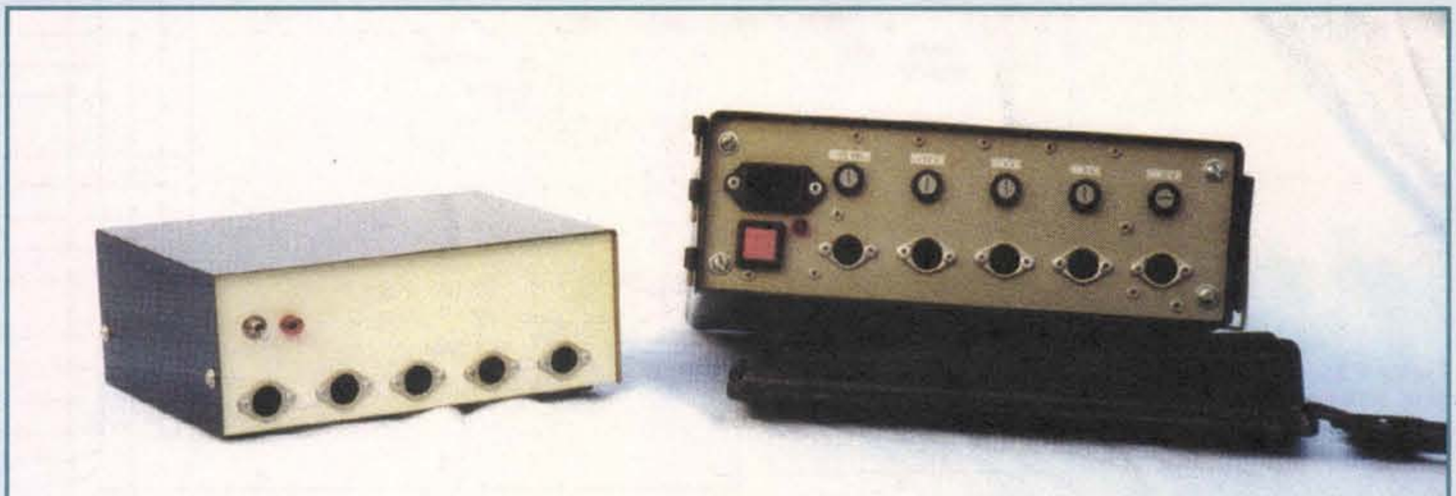
MODULAR INSTRUMENT SYSTEM

A method for power without zillions of batteries



by James Lyman

As an electronics engineer, I often need small, simple custom instruments to test or research a project prior to designing the final instrument.

For years, I've been plagued by how to power each instrument — the question of adding a custom AC power supply or the problem of batteries. Although batteries are relatively cheap and easy to use, I always find them dead the next time I go to use the instrument, and sometimes I also found they've leaked and ruined the instrument.

Using internal AC power supplies eliminates constantly buying batteries, but adds considerably to the cost, size, and weight of each instrument, as well as having to do more sheet metal work.

The only alternative was using external lab power supplies connected via patch cords to panel style banana jacks, but in addition to tying up power supplies, this made a tangled mess of connecting wires. After accidentally applying the wrong voltage to one instrument and damaging it, I looked for a better method.

The method I settled on was a universal AC power supply that provided four different unregulated voltage sources. Most of my instrument designs use ±12 volts for analog circuits and +5 volts for digital logic circuits, but sometimes analog circuits will require lower voltage supplies in the 5- to 6-volts range, so I included a -5 volt supply.

The plan was for a universal power supply that provided four filtered DC, but unregulated voltages of ±12 and ±5 volts. Regulators are placed within each instrument module, but only for those voltages that are used. Since the instruments seldom use more than 100 milliamps, I usually use the TO-92 case, 78LXX/79LXX voltage regulators.

Connecting the instruments to the power supply requires five conductors: four for the voltages and a common for ground. The five-pin DIN audio connector provided the ideal solution. I use a five-pin DIN panel jack (RadioShack PN 274-005) on each modular instrument and standardized the pinouts. The modu-

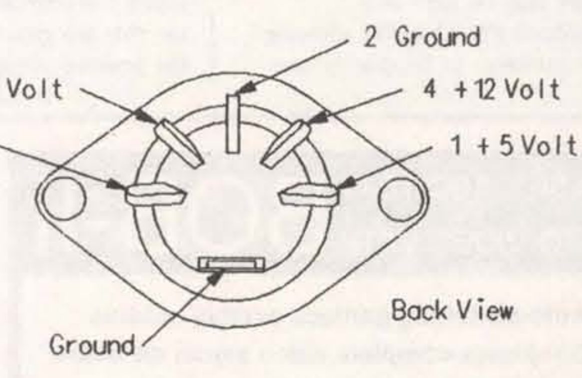


Figure 1: Power Connection

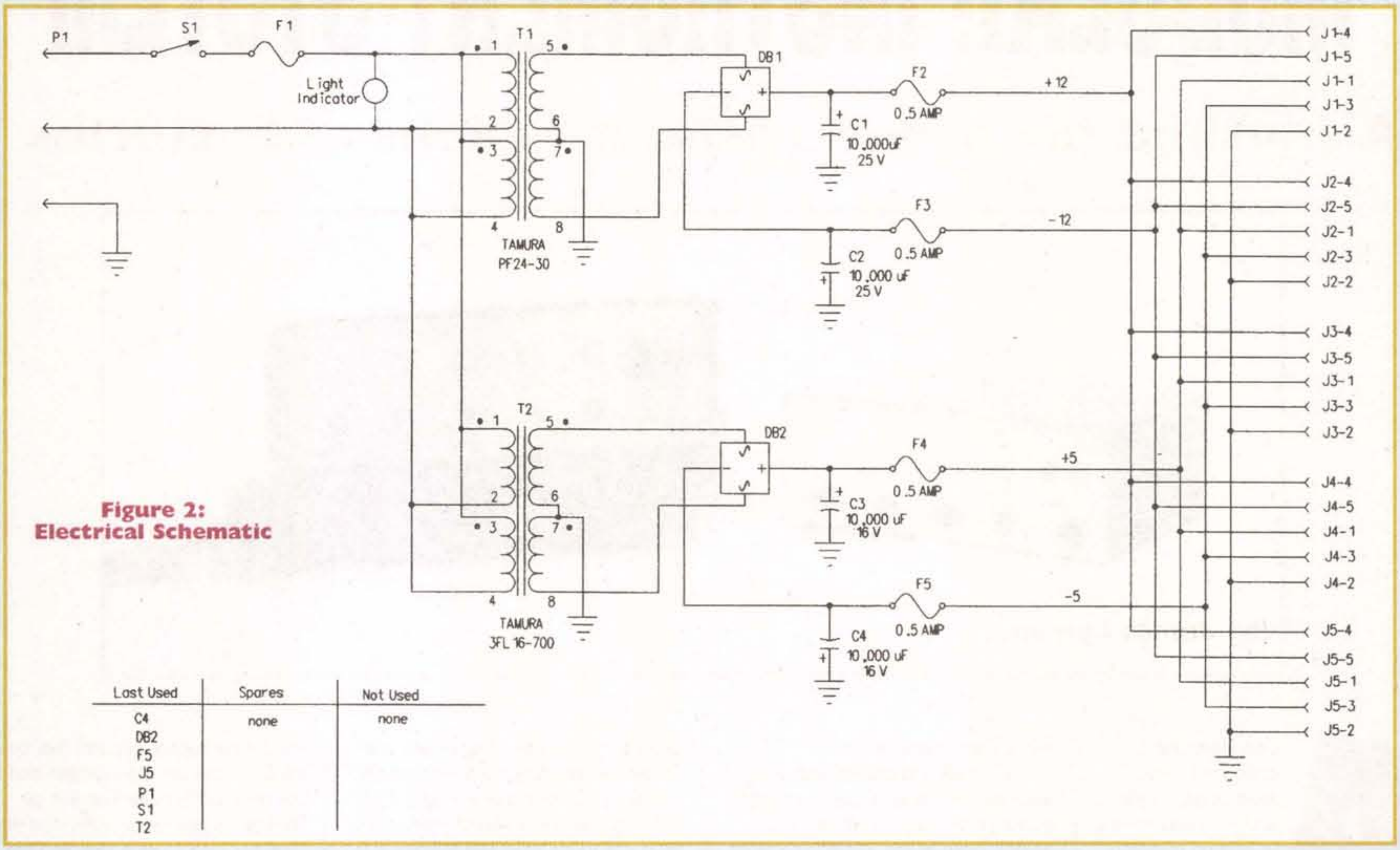


Figure 2: Electrical Schematic

lar power supply uses five of the same DIN panel jacks and connections are made using a six-foot-long DIN connecting cable having a five-pin DIN plug on each end (RadioShack PN 42-2151), allowing the instruments to be quickly connected using these cables.

Figure 1 shows the pinout for the five-pin DIN panel connector as viewed from the rear and from inside the instrument. The two center pins are ground returns, while the positive voltages are on the right side and negative on the left. The lower ground pin is the shield ground while pin 2 is the DC return ground wire, thus ensuring a DC return path if non-shielded cables are used. Note: This pinout is the same for both the power supply and for instruments.

The standard modular power supply consists of two bridge rectifiers and four filter capacitors. When building my power supply, I was fortunate to find a surplus transformer having two center tap windings for ±12 and ±5 volts, which greatly simplified the design. Unfortunately, this transformer is no longer available and I've haven't found an "off-the-shelf" transformer with the two different center tap windings, so most likely you will need to use two separate transformers.

As seen in Figure 2, the primaries for each transformer are connected in parallel through the common switch S1. To ensure the regulators can function, a three-volt margin is required — therefore, the 12-volt supplies require an RMS output of 15 volts (12 + 3) per winding, and the five-volt requires an eight-volt RMS output (5 + 3).

This voltage requirement is for each side of the center tap windings, so the transformer's voltage ratings are 30VCT and 16VCT, respectfully. Since the 78LXX series regulators are rated at 100 milliamps, and there are five instrument outputs (J1 through 5), the output for each transformer needs to be at least 0.5 amps.

The transformers specified in this article are rated at 0.75 amps which gives plenty of margin. Note that these transformers have dual

primaries that can be wired for either 120 or 220 volts, so for 120 volts, the primaries must be wired in parallel, as well as in phase.

The secondaries are wired in series to give a center tap that connects to ground, with a diode bridge connected to give a split voltage supply output. Each output has a 10,000 microfarad filter capacitor that gives about 0.5 volts ripple with a 500 milliamp output.

With the additional filtering and voltage regulator in each instrument, I haven't had any problems with AC noise. Almost any diode bridge will work although using a package with a screw mounting hole simplifies assembly by allowing you to mount it to the chassis then use its stiff wire leads as terminal lugs.

Fuse F1 is in series with power switch S1 for protection should something short the AC power. Each of the output voltages has a fuse (F2-F5) to guard against any shorts from an instrument. These may be mounted internally, but I've found panel mount fuse holders more convenient, plus you can quickly check for power if an instrument doesn't seem to be working. Each voltage output is connected to its corresponding pin of each DIN connector, J1 through J5.

Since the power supply circuit is so simple, no printed circuit board is needed and instead point-to-point wiring is used. All of the components have terminal lugs or heavy stiff lead wires which may be used as terminal lugs. The filter capacitors are mounted to the chassis using plastic wire ties and tie holders, which have self-adhesive backs allowing you to stick the holder onto the chassis floor, then secure the capacitor with a wire tie around the capacitor and through one of the holes of the tie holder.

Modular Instruments

Most of my modular instruments are simple circuits usually comprising a circuit function block such as an amplifier, precision detector, active filter, comparator, or buffer amplifier. These circuits usually have one to three integrated circuits, so an instrument such as a comparator may have an op-amp for input buffering, a comparator integrated circuit, and a TTL buffer for the output.

Through experience, I have adopted some general design standards for instruments concerning inputs, outputs, and power. As stated before, power is limited to ±12 and ±5 volts although sometimes I use ±6 volts. Current is 100 milliamps per voltage with each instrument. In 10 years of building these modular instruments, only once have I need to exceed this 100-milliamp limit.

Input Impedance

In general, I give all signal inputs a one-megohm resistive impedance and use a 0.1 microfarad coupling capacitor for AC inputs. Refer to Figure 3. I usually place an SPST switch across the coupling capacitor to allow selection of AC or DC coupling, such as used on an oscilloscope. I use this option even if I don't anticipate needing it because it adds so much versatility to the instrument.

The op-amp is a source follower configuration giving a unity gain and a very high impedance in parallel with the input resistor, so the input impedance is just the resistor's value. The output from the op-amp then goes to the circuit.

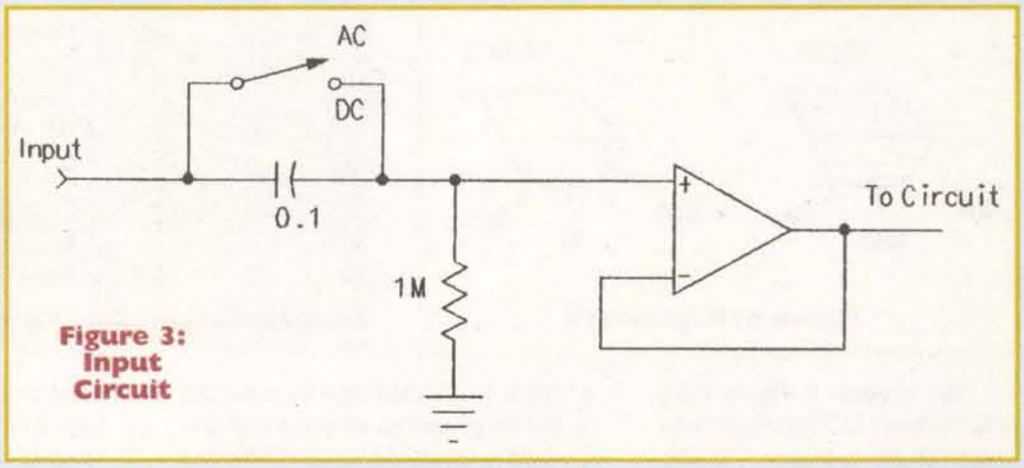


Figure 3: Input Circuit

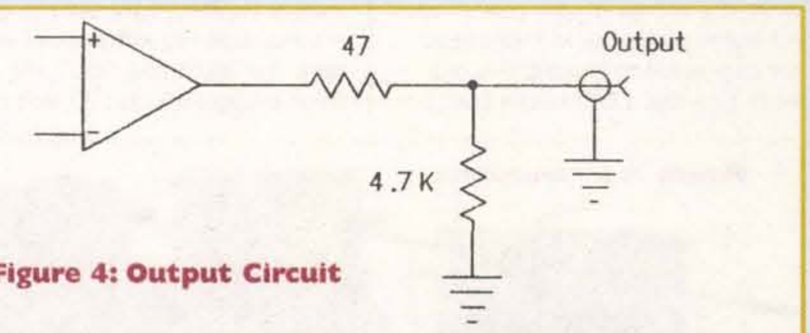


Figure 4: Output Circuit

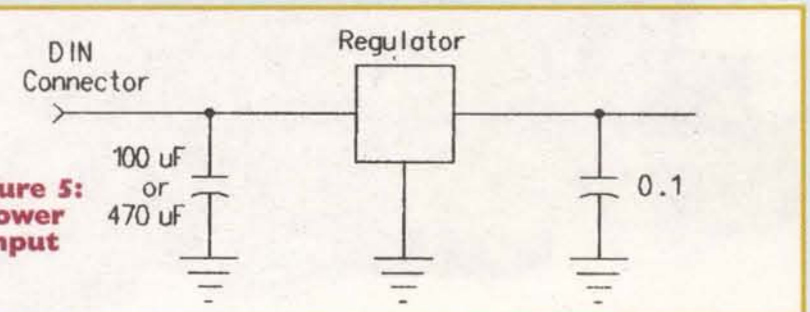


Figure 5: Power Input

Output Network

I almost always used BNC connectors for both input and output which allows several modular instruments to be interconnected using short BNC cables. It's poor design practice to connect an op-amp's output through a coax cable to some unknown impedance, because the op-amp needs a DC return path.

If the load has an AC coupling capacitor, then there is no DC return path plus the output is connected to a highly reactive load, something that many op-amps don't like.

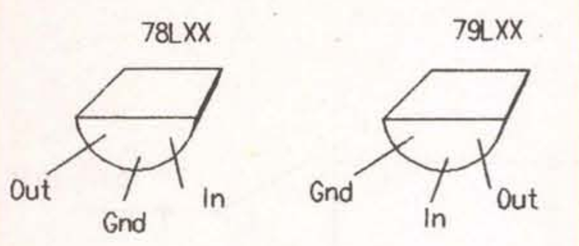


Figure 6: Regulators

Ref. Desg.	Qty.	Nomenclature	Part Number
C1,2	2	10,000 uF Electrolytic Capacitor, 25 V	P6480
C3,4	2	10,000 uF Electrolytic Capacitor, 16 V	P6447
DB1,2	1	Full-wave Diode Bridge	GBPC6005
F1-5	5	1/4 x 1-1/4 inch Cartridge Fuse, 0.5 Amp, 250 Volts	F314
J1-5	5	Five-Pin, Panel Mount Receptacle Circular DIN connector	275-1014
P1	1	AC Connector, Panel Mount	CCM1400
S1	1	Single Pole, Single Throw Switch, Panel Mount	
T1	1	Power Transformer, 120 VAC, 30 VAC@0.7 Amps	MT1124
T2	1	Power Transformer, 120 VAC, 16 VAC@0.7 Amps	MT1111

NOTE: Part Numbers are Digi-Key part numbers.

PARTS LIST

The network in Figure 4 provides a direct DC return path to ensure stable operation. The network is a voltage divider (the 47 and 4.7 Kohm resistors) with one resistor connected to ground. This network provides a DC return path, but since it is a voltage divider, it also introduces a small amount of error. For a one-volt output, the actual output is 0.991 volts which means a 0.99% error. This error is usually less than what is expected for this class of instruments and therefore is not a problem.

Figure 7: Instruments

Power Inputs

As seen in Figure 5, the input of each voltage from the modular power supply has an additional filter capacitor followed by a voltage regulator, then a high-frequency decoupling capacitor. A five-pin DIN connector — the same as used for the power outputs of the modular power supply — is used for power input.

If an instrument uses a voltage, then its corresponding DIN pin is connected to a regulator circuit but, if not used, then don't waste a filter/regulator. For most circuits, I use a 100 uF input filter capacitor before the voltage regulator, but for low noise applications, I use a 470 uF capacitor.

Don't forget to reverse the filter capacitor's polarity for the negative supplies, that is, its positive terminal must go to ground. Each regulator has a 0.1 uF capacitor from its output to ground to surpress high-frequency noise. The small TO-92 case voltage regulators are used to give a maximum of 100 milliamps of current. The 78L05 and 78L12 are used for the positive 5- and 12-volt supplies while the 79L05 and 79L12 are used for the negative 5- and 12-volt supplies.

Figure 6 shows the pinouts for the positive voltage (78LXX) regulators and the negative voltage (79LXX) regulators. Note that they have completely different pinouts, so take care when installing them. These regulators are cheap, yet very effective, and I have experienced no power regulation problems when using them in any of my modular instruments.

Figure 7 shows my inventory of modular instruments which I've built up over the years. Most of these instruments are built in aluminum P-box enclosures sold in RadioShack stores. The 2 x 3 x 5 inch box (part number 270-238) which sells for less than $3.00, makes an ideal case for most instruments.

Since these instruments are one-of-a-kind "quick put-togethers," I build them on a blank piece of copper circuit board using the dead bug method. I bend the pins of integrated circuits out horizontally and wire the components together point-to-point. The integrated circuit is held in place by soldering the chip's ground pins to the surface of the copper circuit board.

Other components that connect between ground and the chip further hold the integrated circuit in place. I use a single screw to attach the circuit board to the inside top of the P-box. Controls, connectors, and switches are located on the two ends so they are easily connected to the circuit. This allows the bottom shell to be removed and replaced without having any connecting wires that need to be disconnected and later reconnected. Being able to quickly remove the bottom makes it easy to work on, or test an instrument, as well as being able to operate it with the case open.

Usually, I place all controls on one end, which has an area of only 2 x 3 inches, so space is at a premium. To help conserve space, I use RadioShack's microminiature toggle switches, part numbers 275-624 for a SPST, 275-613 for a SPDT, and 275-626 for a DPDT switch. These switches have a very small body which allows them to be positioned around bulkier components such as potentiometers.

When placing BNC connectors, be sure to leave enough room for your finger and thumb so you can twist the BNC's connector shell. For labels, I use Brother's P-touch Home and Hobby label maker with silver tape. I set the letter format to small letters with frame outline, then use scissors to trim the label to the frame outline. These labels adhere very well to the bare aluminum surface and make for an attractive, yet durable, panel.

With a power supply which provides power for up to five modular instruments, I can quickly "lash up" a test set to perform an experiment or gather data. Instrument modules are interconnected with short BNC cables, such as the three and six foot long RG-174 cables sold by Jameco (part number 111472 and 111481) that sell for only a few dollars.

A typical lash up is shown in Figure 8 which consists of a Variable Gain Amplifier, Tunable Low Pass Filter, Precision Detector, and a 50-ohm Buffer Amplifier. Such a lash up would be used to condition a signal prior to data acquisition. I've made lash ups for data acquisition, feedback control systems, monitoring with standard test instruments, and to enhance or expand conventional instruments capabilities.

I've found modular instruments to be so useful, that I built a second power supply in a surplus army ammunition box for use in the field. I'm sure you will find this technique to be useful in your design work and, after you have built up a good selection of instruments, you will be suprised how often you use them. **NV**

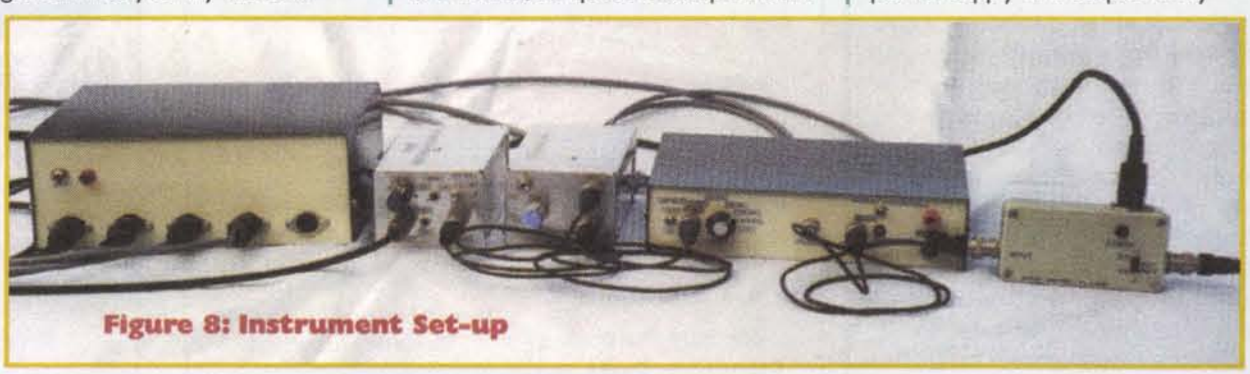


Figure 8: Instrument Set-up

Build a Shaded Pole AC Motor

by Richard Panosh

In 1821, Michael Faraday demonstrated that a continuous rotary motion could be produced by running a current through a wire in the presence of a magnetic field.

Many pioneers followed in a nearly fruitless search to produce a commercially successful DC (Direct Current) motor. These early attempts failed because the source of electrical power was only available from batteries that were both inefficient and made with expensive metals.

Electrical power was unable to compete with steam-generated power produced from cheap coal and water. Early development was aggravated by this situation and financial funding was nearly nonexistent for further development.

In the 1870s, a number of inventors and experimenters learned the principle of the self-excited DC generator that would make electric power commercially practical. At about this same time, they learned that the action of a generator and a motor were reciprocal.

This discovery was widely publicized in 1873 by the French engineer, Hippolyte Fontaine, who noted the results that occurred when a worker mistakenly wired two generators together.

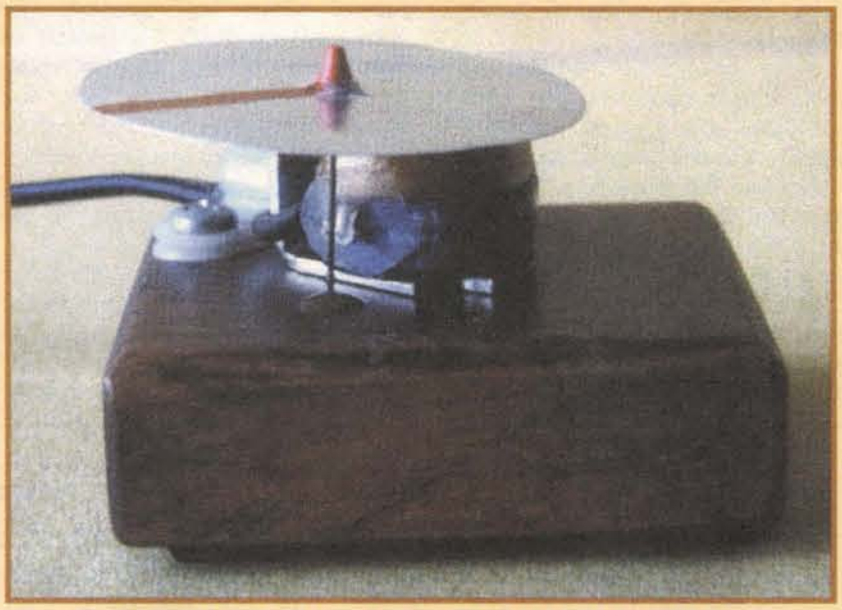
By the mid 1800s, the need for a cheaper and cleaner means of urban transportation presented a potential market for electric motors. Growing cities had already harnessed the horse to pull a car, but it appeared that an electric motor might be cheaper. In 1897, thousands of visitors were transported by the first practical motor-driven vehicle developed by Werner von Siemens at the Berlin Exhibition.

The theory of DC electromagnetic machines had advanced considerably. Improved magnetic circuits and more rugged mechanical designs were being introduced. Heavy sparking of the commutator had been tamed by the introduction of carbon brushes that replaced the earlier copper brushes.

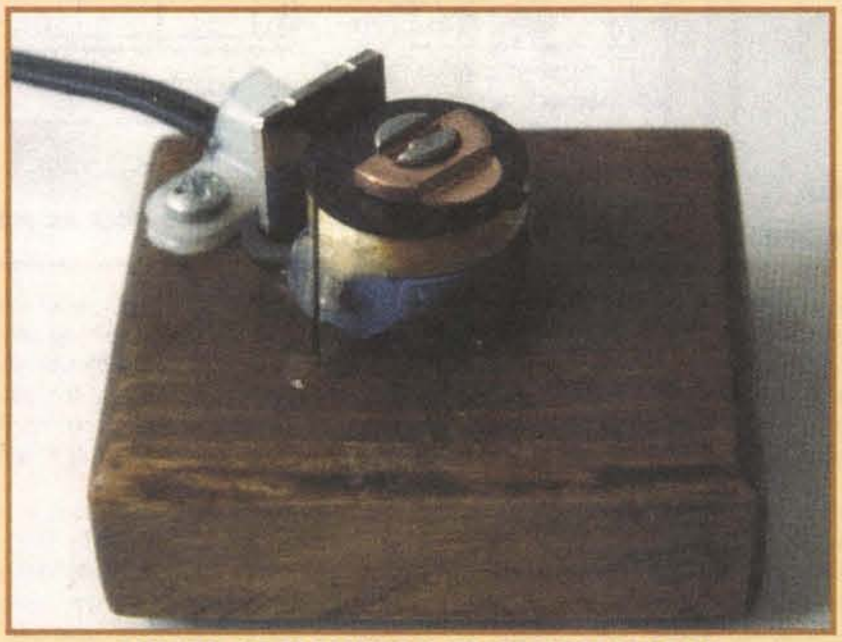
By 1890, small DC motors were being built in large quantities to power fans, sewing machines, and numerous other light tasks. In spite of these accomplishments, the use of DC motors was seriously hampered since DC power could only be transmitted a few miles. The advantage that AC (Alternating Current) power could be transmitted economically over long distance had already become obvious, but no practical AC motor existed.

Unlike the development of the DC motor that progressed from crude theories to what-works, the development of the AC motor required advancements in the theory of AC.

In 1888, an Italian professor — Galileo Ferraris — published an account of his experiments. From the observation of two light waves out of phase, he was led to the concept of a rotating magnetic field that was the resultant of two alternating magnetic fields 90° out of phase. He demonstrated that a single AC current could be split into two out-of-phase magnetic fields and that the resultant fields could produce rotary motion, but unfortunately he concluded that such a motor was only a laboratory curiosity and would never result in a practical motor.



MODEL OF FLEMING & THOMSON MOTOR



MODEL OF FLEMING & THOMSON MOTOR WITH ROTOR REMOVED

Have you ever considered how many electric motors serve you each and every day? Electric motors serve you in numerous ways, from your toothbrush, to your computer, and the list is almost endlessly.

Independent of Ferraris, Nikola Tesla applied for a patent on an induction motor operated by rotating magnetic fields in 1887. Very comprehensive patent coverage was issued during the period from 1888 to 1896 and covered most of the features of AC motors, including multiphase systems.

By 1893, both Westinghouse and General Electric had successfully introduced AC induction motors for industrial applications. The completion of the Niagara Falls power plant in 1896 insured the financial success of these new AC motors and generators. Most of the major features of both DC and AC electrical systems, as well as the associated equipment, were in place by 1900.

While two out-of-phase currents can produce a rotating magnetic field to power an AC induction motor, a simpler design employing only a single coil with a shaded pole is illustrated in Figure 1.

Each pole of the stator is slotted so that a portion of the pole can be encircled with a short-circuited winding, referred to as the shading coil. The main winding produces a magnetic field as illustrated.

Since the currents induced into the shading coils are a function of the rate of change of the main flux, the resulting field from the shaded poles is out of phase and lags the main field. The result is to produce a rotating magnetic field that tends to drag the rotor around in the same direction.

This design was introduced by John Fleming around 1890. During the following years, Fleming would help Guglielmo Marconi design his equipment for the first transatlantic wireless message in 1901 and, in 1904, he would receive a patent on his "thermionic valve" (the first vacuum tube).

About the same time that Fleming introduced the shaded pole design, Elihu Thomson patented the design in the United States. Thomson's company would merge in 1892 with the Edison General Electric Company to become the General Electric Company.

This same principle — as used in the design of the shaded pole motor — is also used in the design of AC relays, but for a different reason. Without the shaded coil, the

force required to hold the armature closed would become insufficient each time the current goes through zero and result in unreliable operation and produce a loud chatter.

In the case of an AC relay, the shaded pole produces a delayed magnetic field that continues to hold the armature securely closed while the main field goes through zero.

Unlike other AC induction motors that require two magnetic coils to produce a rotating magnetic field, the design of John Fleming and Elihu Thomson requires only a single coil.

The original design of the shaded pole motor differs from that illustrated in Figure 1 and is closer to the one that we shall describe here (see Figure 2 to demonstrate the concept). It has only a single pole and lacks the more efficient magnetic circuit and improved rotor design of today's art.

Since an AC relay utilizes the same principle as a shaded pole motor to produce a rotating magnetic field, it is employed for the magnetic field of our shaded pole motor. This saves winding several hundred turns of wire and slotting the pole to install a shading coil. Almost any 120 VAC power relay coil with two or three poles should work, as most of them operate at about two or three watts of power.

The specific relay used (Dayton 5X810) in this design is given in the parts list, as well as several equivalent relays. The armature, contacts, and spring can be discarded, only the coil is used for this project.

The rear of the magnetic return was cut down to be approximately level with the pole as illustrated in Figure 2 and the coil was mounted on a small wooden base that measures about 2-1/2" square. A thin 16-gauge electrical cord was soldered to the terminal to provide power. The contacts can be insulated with silicone rubber or heat shrink tubing.

The rotor for our shaded pole motor is made from thin aluminum. Generally, copper is used for the rotor since its resistance is low and the induced currents will be high. However, aluminum is light, readily available, and easy to fabricate.

The resistivity of aluminum is about 1.6 times greater then copper, but its density is only half that of copper. The lower density makes up for the higher resistance since the bearing friction is lower, as well as the rotor inertia. Flat 0.003" aluminum shim stock (available from hobby shops or hardware stores) was used for the rotor.

A disc of about 2" diameter was drawn with a compass. The compass point was used to mark the center of the disc, being careful not to puncture the aluminum with the point. The aluminum is soft enough that it can be carefully cut with a sharp pair of ordinary scissors.

A 1/8" hole was punched in the center with a metal hand punch. If the punch is somewhat worn, a better hole may be punched by backing the thin aluminum stock with a heavier piece of paper card stock or plastic stock. It will be helpful to mark the aluminum rotor on the top surface with an indelible marker to serve as a reference index.

The central rotor bearing is made from the top of a "3-in-1" multi-purpose oil can (3 fluid oz. size). The closed end of the red plastic spout was cut off with a razor blade about 3/16" from the top. This bearing is carefully glued to the hole in the aluminum disc with a drop of five-minute epoxy.

After the epoxy cures, the rotor should be positioned on the sharp end of a pin to check the static balance. If the pivot or disc is not centered, the disc will droop to one side. By gently blowing on the disc, it can be made to rotate to see if it always tends to droop in the same relation to the index mark. If one side is found to be heavier, trim a small amount off the edge of the aluminum disc with the scissors until a reasonable balance is achieved.

The rotor is positioned next to the relay coil on a short piece of 0.02" steel wire which serves as the shaft. The top end of the wire should be nicely rounded with emery paper to remove any rough edges. Alternately, a common pin can be used for the shaft.

The shaft is located in the wooden base to be as close to the coil as possible and directly opposite the center of the coil. This location should allow the rotor to completely cover the magnetic pole and extend about 1/4" beyond. The height of the shaft is adjusted so that the aluminum rotor is about 1/16" above the pole face and rotates freely. The final shaft height can be secured by placing a drop of five-minute epoxy around the end of the shaft that terminates in the wooden base.

When the coil is energized, the aluminum rotor should spin in the direction of the shaded pole. The speed of the rotor is about one revolution per second. If you display the motor in a windy area, you will have to provide a clear cover to prevent the rotor from being blown off.

An acrylic hemisphere for displaying models or the bottom third of a two-liter soft drink bottle will provide a suitable cover.

The coil of the motor will run warmer than the original relay since the magnetic circuit is leaky and the inductance of the coil has been reduced due to this effect. The original relay coil had a temperature rise of about 10°C above ambient and as a motor, the temperature rise was about 32°C. A metal base such as aluminum could be used instead of the wooden base to act as a heatsink to reduce this difference.

Some improvement might be possible by making the rotor larger so that the magnet can produce more torque on it. More power and better balance of the motor can be achieved with two or three shaded pole coils located equally spaced around the central shaft. Also additional shaded pole coils could be located above the lower set.

A radially laminated rotor should also result in improvements, but would require a great deal of additional work and effort to achieve balance. Changes such as these are evident in the evolution of the modern shaded pole AC motor.

The single coil model is simple and this same simplicity cloaks its *muy misterioso* operation. For demonstrations, the rotor can be easily removed to show that nothing has been hidden beneath it.

There are no brushes, commutator, additional phasing coils, or other peripheral hardware required by this type of motor. Its operation can only be deduced from the concept of an invisible rotating magnetic field that is developed from a single coil. It makes an excellent display of the early Fleming-Thomson motor and a terrific science project. **NV**

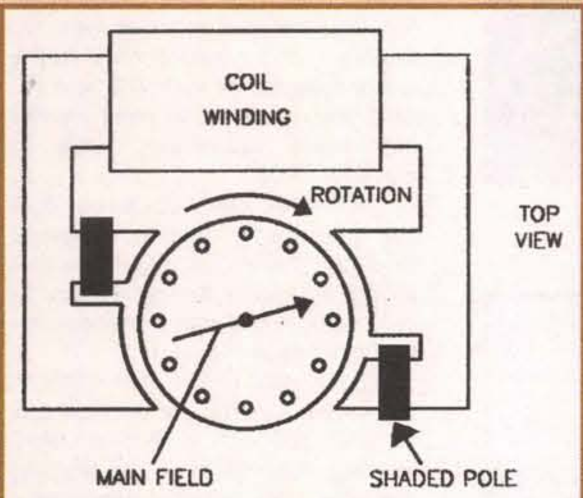


FIG. 1. MODERN SHADED POLE AC MOTOR

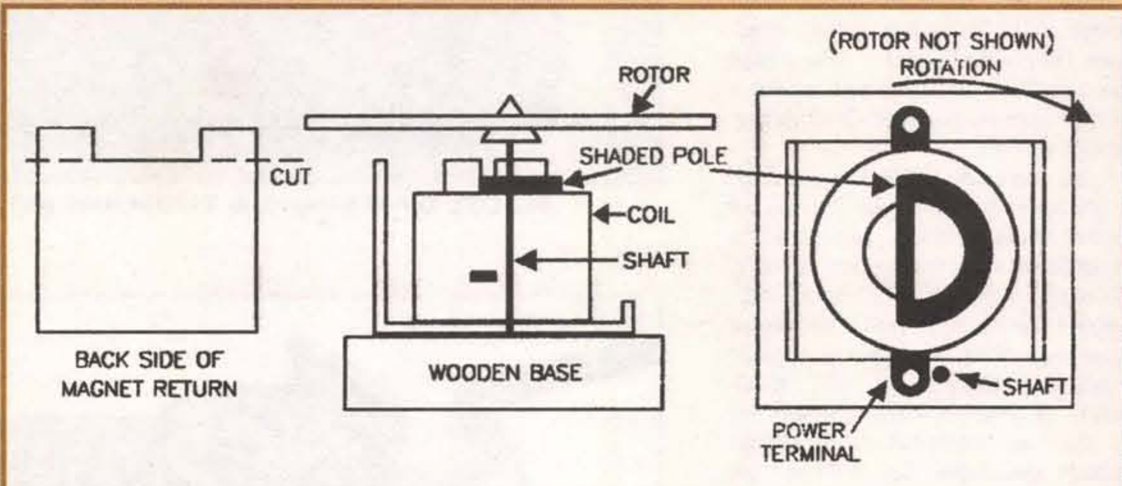


FIG. 2. FLEMING & THOMSON SHADED POLE AC MOTOR

Parts List

1	Rotor, 0.003" Aluminum shim stock to make 2" dia. disc
1	Shaft, 0.020" dia. steel wire or pin, about 1-1/4" long
1	Bearing, 3/16" plastic tip from "3-in-1" oil spout
1	Base, 2-1/2" square mounting wood or plastic base
1	Power cord, 16 Ga. 120 VAC power cord
1	Glue, five-minute epoxy
1	Insulation, Clear Silicone Rubber
1	Coil, 120 VAC relay coil, 2-3 watts, DPDT or 3P3T
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A line out cable will allow for the included Voice Manager software on CD-ROM to download messages and dictation to a PC under Windows '95 or '98. The telephone adapter will record phone messages. An external microphone gives users exceptional voice recording in large lecture halls or meeting rooms. Two "AAA" batteries (inc.) give 10 hours of continuous use.

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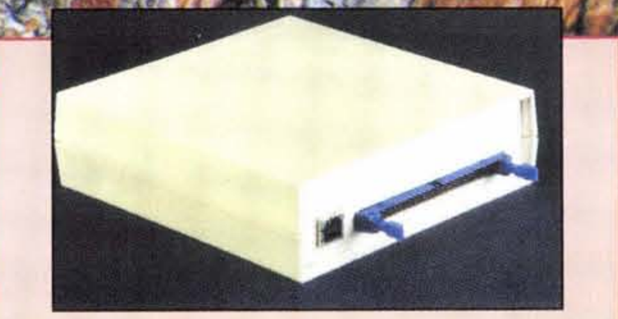

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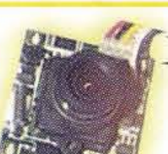

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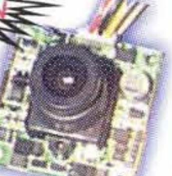

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